Music, context-based inquiry, and computer simulation as engagement strategy

Grace Djan[1] **and Miriam Lemmer**[1]
Northwest University, Potchefstroom South Africa

E-mail: gdjan@hotmail.com

Abstract. The standard of engagement in science classes is fundamental for effective learning. Creating an active learning environment is essential for engaging learners. However, implementing engagement is a critical problem that teachers face. Due to the large variety of engagement strategies teachers often do not know what strategy to use or make use of. This paper attends to the factors that could influence the choice of an appropriate engagement strategy. The objective of this research study was to explore music, context-based inquiry, and computer simulation as engagement strategies as well as the impact of these strategies on the four components (behavioural, affective, cognitive, and authentic) of engagement. The application of mixed methods comprised of a pre-test and post-test questionnaire (quantitative), video recording and semi-structural interviews (qualitative). The general results that follow from this research is that the choice of an appropriate engagement strategy does not only depend on the topic that is taught, but also on other factors namely teachers' acquaintance with the strategy, the learning environment, the background of the learners, the engagement components that need attention as well as the amount of time available. A combination of the three engagement strategies is proven to enhance learning engagement.

1. Introduction

Engagement is viewed as active involvement, curiosity, and the drive to learn and achieve. Learning, that involve active participation of students using different learning strategies creates active learning. [1] found that a combination of technology-infused strategies and online approaches such as Google Classroom and "flipped classrooms" using a variety of well-planned activities promote engagement. With the normal South-African context in mind, we focused instead on learner engagement through three engagement teaching strategies that can be used in face-to-face classrooms. Namely music, context-based inquiry, and computer simulations.

The purpose of this paper is to determine the impact of these three engagement strategies on the four components of engagement, namely cognitive, affective, behavioural, and authentic engagement. Given its wider scope, this paper serves to examine factors that affect science teachers' choice of strategy based on how these strategies influence learner engagement. Therefore, the research questions are: what is the impact of music, context-based inquiry, and computer simulation as engagement strategies on the four components of engagement? What factors may affect the choice of a teaching strategy?

1.1 Music and its importance to learning

Music is a pedagogical approach to science education that is appropriate to provide an alternative science teaching and engagement strategy [2]. Firstly, it activates prior knowledge, promote critical thinking which is a crucial aspect of learning [2], [3]. Secondly music may promote engagement, excitement, and creativity, although the excitement may sway learners from complying to class discipline [4], [5].

1.2 Context-based and its importance to learning

Context-based strategies bridge the gap between learning in class and everyday life which include solving problems that are relevant to students [6], [7]. This strategy promotes meaningful science learning and successful transfer of knowledge across different contexts as well as between the classroom and the real-world [8], [9]. The use of the context-based strategy may promote learner engagement with content, learner responsibility to learn, and active involvement [10], [11].

1.3 Computer simulation and its importance to learning

Computer simulation was pioneered as a scientific tool in meteorology and nuclear physics immediately after World War II and has now expanded into a number of research disciplines [12]. Even though computer simulation can slow down learners' interpersonal skills [13], it can be used to teach complex physics [14]. Additionally, it may provide positive contribution and significant improvement in the performance of students [14], [13], [15].

2. Design and method of empirical study

Fifty in-service secondary school science educators of the North-West province participated in two Saturday's workshops. The intervention entailed the use of music, context-based inquiry, and computer simulation to engage the participants to learn basic concepts of the Periodic Table. In order to accomplish this, a reliable questionnaire with valid constructs was compiled by the researcher. The questionnaire served as pre and post-test; followed-up by semi-structured interviews.

The application of sequential explanatory mixed method in this study procedure provided the opportunity for the researcher to combine elements of quantitative and qualitative research approaches for breadth and depth of understanding, validation, corroboration, and verification [16], [17].

The questionnaires used in the pre-test and post-test contained different groupings of questions that formed constructs. All questions were categorised into phases: Phase 1 music, Phase 2 context-based inquiry, and Phase 3 computer simulation. Each phase was assessed with questions in four constructs that relate to the four components of engagement, namely cognitive, affective, behaviour and authentic. Each construct contained five sub-questions in the form of a statement with four Likert scale options. Options 1 and 2 correspond to strongly disagree or disagree with the statement, while options 3 and 4 indicate agree and strongly agree respectively. A statistical analysis was done to determine the reliability and validity of the constructs, to produce frequency tables and compare pre- and post-test results.

Though all fifty participants took part in completing the questionnaire, six participants were interviewed after completion of the interventions. Six is a convenient and manageable number to represent the sample of teachers in the semi-structural interview. The results were transcribed, and trends were determined.

3. Results

3.1 Reliability and validity of constructs

To answer the first research question, the pre- and post-test results were compared with the aid of Cohen's effect sizes. This requires reliability and validity of the questionnaire which were respectively established by Cronbach's alpha coefficients and factor analysis. Table 1 gives the Cronbach's alpha coefficient for the sets of questions pertaining to each phase (or strategy). Phase 1 questions relate to

music, phase 2 to context-based inquiry and phase 3 to computer simulation as engagement strategy. Three participants did not complete phase 1 questions while four did not complete phases 2 and 3.

Table 1. Reliability of sets of questions per phase.

Sets of questions	*N*	Cronbach's Alpha	Internal consistency
Phase 1 Music	47	0.87	Very good
Phase 2 Context-based inquiry	46	0.86	Very good
Phase 3 Computer simulation	46	0.89	Very good

All the sets of questions on the strategies proved to have been answered consistently with a high Cronbach's alpha value between 0.85 and 0.9. Each of these sets were then divided into the 4 constructs of 5 sub-questions, each pertaining to a component of engagement. All constructs also yielded Cronbach alpha values larger than 0.8 and are thus reliable.

Construct validity was determined with the aid of a factor analysis. According to the results, the number of factors retained by the Mineigen criterion was 1 for each of the constructs. Low variation in communalities confirmed that the constructs contained valid, interrelated questions.

3.2 Cohen's effect size

Cohen's effect size, d, for dependant groups, were used to compare the averages of the constructs before and after the intervention. The two matched groups were the pre and post-test averages obtained for each construct. The descriptive statistics includes interpretation of comparisons between the group means as illustrated in Table 2. Practical significance, which indicates the degree to which the difference is large enough to have an impact in practice, follows from Cohen's d-values, namely small effect: d = |0.2|; medium effect (noticeable with the naked eye): d = |0.5|; large effect (practically significant): d ≥ |0.8 The constructs with noticeable d-values are marked in bold in Table 2.

Table 2. Descriptive statistics of constructs for pre- and post-tests.

	Constructs	N	Pre-test Average %	Post-test Average %	Cohen's effect sizes (d)
MUSIC	**Cognitive**	**47**	**80.50**	**88.25**	**0.58***
	Affective	45	84.25	85.75	0.24
	Behaviour	**45**	**80.75**	**87.00**	**0.51***
	Authentic	47	83.50	85.50	0.21
CONTEXT-BASED	Cognitive	45	84.75	84.50	0.10
	Affective	46	81.50	84.50	0.13
	Behaviour	46	85.75	85.75	0.02
	Authentic	47	83.50	84.25	0.01
COMPUTER SIMULATION	**Cognitive**	**47**	**87.25**	**93.25**	**0.51***
	Affective	46	83.75	88.50	0.29
	Behaviour	46	85.25	88.50	0.24
	Authentic	45	82.25	90.00	0.23

For all constructs, except context-based cognitive, the average scores were higher in the post-test than the pre-test. This implies that the teachers' perception after the intervention changed positively. A general shift towards the Strongly Agree option was observed in the post-test results.

The interventions had a medium effect that is noticeable with the naked eye on the following constructs (with $0.5 \leq d \leq 0.8$): Music cognitive, Music behaviour, and Computer cognitive. For example, for the cognitive construct of music there was a difference in average of nearly 8% in pre and post-test scores. The d-value (d=0.58) indicates that the music intervention had a medium effect on the perceptions of the teachers regarding cognitive engagement through music, while the effects on affective and authentic were small ($0.2 \leq d \leq 0.5$).

The constructs under context-based inquiry showed no significant difference between pre and post-test responses, with a consequent low d-value ($d<0.2$). On the other hand, computer simulations impacted positively with small to medium effect on all four engagement components.

3.3 Factors that influence the choice of strategy

Both the questionnaire and interview results contributed to answering the second research question. The quantitative results showed the impact of the interventions on teachers' perceptions regarding the association of three teaching strategies with four components of engagement (Table 2). The factors characteristic to the components of engagement with the largest percentage change from the pre to the post-test for each strategy are described in Table 3.

Table 3. Description of some factors related to teaching strategies that enhance learner engagement.

Teaching strategy	Engagement component	Description
Music	Cognitive	Aid learning scientific concepts. Useful for enhancing understanding of relationships.
	Behaviour	Enhance participation in class. Promote concentration on content.
Context-based inquiry	Affective	Arouse interest to learn and promote enjoyment. Create an environment with a pleasant working climate.
Computer simulation	Cognitive	Useful for promoting conceptual understanding and mastering of content. Create opportunity to visualize abstract concepts. Assist students to engage in science problem solving in a meaningful way.
	Affective	Improve classroom environment by creating a friendly working climate. Promote enjoyment and passion to pursue STEM career.
	Authentic	Create opportunity to use variety of resources with activities that match real world tasks. Enhance collaboration and teamwork.

According to Table 3, music strategy mostly enhances cognitive learning of scientific concepts and is useful for understanding relations amongst concepts. Music also accomplished behavioural factors such as concentration and active participation. Context-based inquiry only yielded a positive change in favour of affective engagement. This entailed arousing interest and creating a pleasant working climate. The interventions further increased teachers' perceptions that cognitive, affective, and authentic engagement can be achieved with the aid of computer simulations. Prominent factors include visualisation of abstract concepts (cognitive), a friendly working climate (affective) and enhancement of collaboration and teamwork (authentic).

With regard to the qualitative results, the following interview quotes by the interviewees provide examples that confirm quantitative results shown in Table 3 concerning the engagement components relevant to the different strategies.

- Music: "music helps with memorisation of facts, definition and things like that''
- Context-based: "It is also helpful with concept of the content and abstract.'' "Experiment brought out the interest.'' "Doing practical fascinates learners.''
- Computer simulation: "Much easier to use.'' ''Do not need lots of preparation." "Do not need a lot of resources.''

Apart from the effect of engagement, the interviewees also brought out the following factors that may determine the strategy that teachers use:

- Teachers' acquaintance and knowledge of the strategy:
  "You need to know it yourself of how you must maneuver it from one side to the other, so you do not flop."
- Content to be taught:
  "How do one put those calculations of formulae in terms of music?"
- Time available:
  "It can work … but the time to create the music will take all your time."
- Learner background and personality
  "…the very shy person who you thought was not interested in reading or … they even have more knowledge than those who actually pass."
- Learning environment
  "It arouses and creates interest and enjoyment, participation. The group was very inquisitive".

4. Discussion of results

The quantitative results showed that the three teaching strategies impacted at differing intensities on the four components of engagement. The use of music has the highest practical, and noteworthy impact on both cognitive and behaviour engagement followed by affective engagement and the least on authentic engagement. It enhances understanding and application of scientific concepts, more specifically of basic facts and definitions. Furthermore, it promotes concentration and active participation in class.

With regard to context-based inquiry, the teacher participants' perceptions that affective engagement can be achieved, was enhanced by the intervention. This was described by terminology such as interest, enjoyment, and fascination. However, context-based inquiry only had minor effects on perceptions regarding cognitive, authentic engagement and little effect on behaviour engagement. The reason might be that participants, being science teachers, were already accustomed to the application of context-based inquiry and the intervention consequently did not change their perceptions regarding the value of this engagement strategy.

Computer simulation was successful in enhancing cognitive engagement to a medium effect and affective, authentic, and behavioural engagement to a lesser effect. Mastering of content and visualisation of abstract concepts are prominent factors. It also requires less resources than context-based inquiry.

Although engagement was the main focus of the investigation, other factors that could affect the choice of the teaching strategy came to the fore, namely the teacher's acquaintance and knowledge of the strategy, the topic of the lesson, amount of time available, the learning environment and the background and personalities of students.

5. Conclusions and recommendations

In conclusion, it can be postulated that teachers should use all three strategies, music, context-based inquiry, and computer simulation as each has its own beneficial impact on the different components of

engagement. For instance, music can be used in an introductory lesson, for learning basic concepts and definitions, in order to enhance cognitive and behavioural engagement. Additionally, context-based inquiry can be used for learning concepts and application problems and to enhance affective engagement. Computer simulation is ideal for all topics, especially abstract content, and may enhance all the four components of engagement.

In order to engage students, we must be able to understand our students, to select an appropriate engagement strategy for each specific context. A solid understanding of the links between how students engage in learning and how to help students to engage in learning should be further investigated.

References

[1] Nueva N G C and Calica J 2018 Technology-infused approach to learning science: an examination of students learning experiences and academic achievement. *Asia-Pacific Soc. Sci. Rev.* **18** 114-126

[2] Crowther G J, McFadden T, Fleming J S and Davis K 2016 Leveraging the power of music to improve science education *J. Sci. Educ.* **38** 73-95

[3] Miché M 2002 Weaving music into young minds (Albany, NY: Delmar Thomson Learning) p304

[4] Kuśnierek A 2016 The role of music and songs in teaching english vocabulary to students. *World Sci. News.* **43** 1-55.

[5] Murphey T 2013 Music and song-resource books for teachers Oxford University Press. https://books.google.co.za/books?hl=en&lr=&id=rfCdBgAAQBAJ&oi=fnd&pg=PT15&ots=bIHHB38KsP&sig=jTf1RXPFJ0-PA9lj6cCgeXbea3U& Date of access: 21 Dec.2019

[6] Duran M and Dökme I 2016 The effect of the inquiry-based learning approach on student's critical-thinking skills. Eurasia *J. Math, Sci. & Tech. Edu.,* **12** 2887-2908

[7] Walan S and Rundgren S C 2015 Student responses to a context-and inquiry-based three-step teaching model *J. Teach. Sci*. **61** 31-39

[8] Herranen J, Kousa P, Fooladi E and Aksela M 2019 Inquiry as a context-based practice a case study of pre-service teachers' beliefs and implementation of inquiry in context-based science teaching. *J. Sci. Educ*. **41** 1977-98

[9] Gilbert J K, Bulte A M W and Pilot A 2011 Concept development and transfer in context-based Sci Edu. *J. Sci. Educ.* **33** 817-837

[10] Trudel L and A Mētioui 2015 Conditions of implementation of an inductive learning sequence about the Periodic Table in high school chemistry *UMAT.* **3** 529-544

[11] Minne D D, Levy A J and Century J 2010 Inquiry-based science instruction what is it and does it matter? Results from a research synthesis years 1984 to 2002. *J. Res in Sci. Teach* **47** 474-496

[12] Winsberg E 2019 Computer simulations in science, *The Stanford Encyclopedia of Philosophy* (Winter 2019 Ed), Edward N Z (ed.) https://plato.stanford.edu/win2019/

[13] Guy R S and Lownes-Jackson M 2015 The use of computer simulation to compare student performance in traditional versus distance learning environments. *J. Inf. Sci and Inf. Tech,* **12** 95-109

[14] Kunnath B J 2017 *The effect of computer simulations on grade 12 learners' understanding of concepts in the photoelectric effect.* University of South Africa: UNISA. (Dissertation- Master of science in mathematics, science and technology education)

[15] Udo M and Etiubon R 2011 Computer-based science simulations, guided-discovery and students'performance in chemistry *Mod. Appl. Sci.* **5** 211-7

[16] Johnson R B Onwuegbuzie A J and Turner L A 2007 Toward a definition of mixed methods research. *Mixed Methods Res.* **1** 112–133

[17] Tashakkori A and Teddlie C 2010 *Overview of contemporary issues in mixed methods research (In* Tashakkori A and Teddlie C *eds.* Mixed methods in social and behavioural research. 2nd ed. London: SAGE Publications (pp1-45)