Universal Journal of Educational Research 9(9): 1628-1640, 2021 http://www.hrpub.org
DOI: 10.13189/ujer.2021.090903

Creating Indigenous Knowledge Spaces in Physics Learning Environments: Postcolonial Views and Insights from High School Physics Teachers

Mudzamiri Edson*, Govender Nadaraj

School of Social Sciences Durban, University of KwaZulu-Natal, South Africa

Received May 8, 2021; Revised July 12, 2021; Accepted August 22, 2021

Cite This Paper in the following Citation Styles

(a): *[1] Mudzamiri Edson, Govender Nadaraj , "Creating Indigenous Knowledge Spaces in Physics Learning Environments: Postcolonial Views and Insights from High School Physics Teachers," Universal Journal of Educational Research, Vol. 9, No. 9, pp. 1628 - 1640, 2021. DOI: 10.13189/ujer.2021.090903.*

(b): *Mudzamiri Edson, Govender Nadaraj (2021). Creating Indigenous Knowledge Spaces in Physics Learning Environments: Postcolonial Views and Insights from High School Physics Teachers. Universal Journal of Educational Research 9(9), 1628 - 1640. DOI: 10.13189/ujer.2021.090903.*

Abstract The study explores teachers' perspectives on the possibility and necessity of creating indigenous knowledge spaces (IKS) in physical learning environments (PLE) for learning physics in high schools in Zimbabwe. Traditional PLE such as laboratories for learning physics are still dominated by colonized western pedagogical designs and features but can be redesigned in light of the recent debates on Indigenous Knowledge (IK) and Science integration decolonizing agenda. IKS intends to make classrooms physics more accessible and meaningful for both indigenous teachers and learners. In many African countries including Zimbabwe, educational policies indicate the need to integrate IK and IKS in the school curriculum. However, these policies do not provide guidelines on what IK to integrate, where and how to do it in the existing curriculum as well as how to create and facilitate IKS. There are limited studies on IKS and advice on how to transform current educational facilities spaces. This study therefore provides insights on how IK can be integrated in physics through the creation of IKS in the PLE. In this regard, data were gathered from 10 male and 10 female teachers using quantitative (Likert-scale questionnaires) and qualitative data (observations and interviews). The findings suggest that the existing physics PLE are limited in providing IK resources for the teachers. The teachers confirm that IKS can be created in the PLE where indigenous artefacts are incorporated, traditional homestead are modelled, etc. integrated together with existing physics laboratory and school resources. The study recommends a variety of IK resources and strategies in the creation of IKS but it will also require a team effort from teachers, community, and educational authorities in effecting the decolonizing agenda.

Keywords Physics, Physical Learning Environments (PLE), Indigenous Knowledge Spaces (IKS), Decolonization

1. Introduction

Science educators engaging in decolonization are examining and transforming science learning and its teaching environment spaces to include Indigenous Knowledge (IK) and indigenous knowledge spaces (IKS) to make learning relevant and accessible to their learners' cultural backgrounds [1]. Indigenous Knowledge as used in this study is knowledge that is unique to a given culture or society and is acquired through the accumulation of experience, informal experiments and intimate understanding of the indigenous environment [2]. Physical Learning Environments (PLE) are physical educational spaces like classrooms, school grounds, physical resources etc. where teachers and learners work together and engage in authentic activities to promote understanding of knowledge. This study explores the possibility and necessity of creating indigenous knowledge spaces (IKS) in physical learning environments (PLE) for learning of physics in high schools in Zimbabwe. It aims to give insights of physics teachers' views on how IKS can be created in PLE in promoting understanding of physics concepts. Traditional PLE such as standard classrooms and laboratories for learning physics are still dominated by colonized western pedagogical designs and features but can be redesigned in light of the recent debates on Indigenous Knowledge (IK) and Science integration in light of the current decolonizing agenda. Decolonization is the process of deconstructing colonial ideologies of the superiority and privilege of Western thought and approaches [3]. It involves valuing and revitalizing IK and challenging Western assumptions and biases that have impacted on indigenous ways of being and working [3]. Decolonizing the PLE means we create IKS that are inclusive, respectful, and honour indigenous people's culture, skills and experiences.

In Zimbabwe, as well as in other African countries, the educational policies indicate the need for the integration of IK in the curriculum but do not provide guidelines on what IK to integrate, where and how to do it in the existing curriculum and how to create and facilitate IKS. There are limited studies on IKS concerning PLE and advice from indigenous physics teachers on how to transform these educational spaces. The study contributes in making IK effective in teaching by suggesting emancipatory pedagogical techniques and IKS that supports the decolonization and indigenization of physics teaching. Indigenization is a collaborative process of naturalizing indigenous people's intent, interactions, and processes and making them evident in transforming spaces, places, and the philosophy of learning institutions [3]. When indigenization is practiced at an institution, the marginalized indigenous people begin to see themselves represented, respected, and valued and begin to feel at 'home' [3].

IK has been sanctioned by researchers and some educational authorities as a source of local knowledge in the curriculum. Recently, several studies on how to include IK into teaching and learning of science report that it is feasible but will require resources and training of teachers [4,5]. However, there are few studies on IK and Physics but hardly any of IKS in physics [6]. It is anticipated that physics teachers of indigenous backgrounds will highlight ways on how to aligned classroom physics to link with local culture and create IKS in the PLE. There are strong possibilities that IKS in PLE will create appropriate conditions to evoke novel and cultural teaching and learning styles in facilitating learners' physics understanding. The creation of IK space in the PLE reduces the foreignness and abstract nature of physics knowledge content and pedagogy [7]. Most of the relevant teaching and learning resources in science are often found in the local environments of learners [8].

Decolonization and indigenization of the curricula must not only be interpreted as an ideological and philosophical mental and exercise in academia but must be seen to transform the lives of the people in their daily survival and problem-solving activities. Currently physics is taught as isolated topics and quite abstract for learners whereas IK seeks a holistic, practical and connected link to their environment. Thus, the creation of IKS in PLE offers complementary sites to explore physics knowledge in an interrelated and culturally contextual manner rather than the traditional colonized western style of teacher-centered instruction using only western artefacts.

The study is also framed within the social-cultural values that emphasize the importance of culture and context in constructing knowledge and enhancing meaningful learning grounded in the post-colonial theory. IKS play an important role in making the teachers' integration efforts in the classroom a reality as it enhances the accessibility to cultural resources and creates an environment for meaning-making of physics in context. IKS thus provide a cultural dimension in the PLE design to achieve a culturally inclusive constructivist learning environment [9]. McLoughlin and Oliver [9] add that a highly contextualized and culturally aligned PLE are likely to meet the needs of learners for whom they are intended.

Previous studies have largely concentrated on the exploration of the social and psychological aspects rather than the physical attributes of PLE [10,11]. Several researchers have indicated the importance of PLE [12,13] and they suggest a variety of learning possibilities [14]. For example, Strange and Banning [14] add that PLE provides for deeper learner engagement by reinforcing concepts with physical reality thus enhancing learning outcomes [15]. PLE also stimulate excitement and motivation to learn when 'seeing' and 'interacting' with artefacts in context [16]. PLE also provide a diversity of learning possibilities such as strengthening identity and gaining familiarity of knowledge in contexts in promoting meaningful learning. Oblinger [17] argues that PLE carry an unspoken message of silence and power of 'built in' pedagogy like in museums. Built in pedagogy is the design of space/s that impact on learning and teaching and provide affordances upon which social thought, action and interaction can occur [17].

This study sought to offer insights on how IKS can be created in physics as a way of creating a culturally linked and aligned PLE. The indigenous culture embedded in the teacher's instruction and in PLE should be harmonized so that learners will be able to consolidate on what they would have learnt in the lesson and even generate new knowledge on their own as they interact in the PLE. PLE with a mixture of IK and Western artefacts embody pedagogies or a 'tacit curricula' of inclusivity and multiculturalist philosophies, as well as pedagogy of freedom to think creatively. IK integrated in PLE would afford a space for culturally aligned learning processes to occur and trigger curiosity among learners. The authors adopted a view expressed by Mapara [18] that IK dialogues and decolonizing agenda should not dislodge or negate valuable western perspectives and knowledge but seek the integration of IK and Science in solving current problems.

2. The Problem in Context

The current major problem is that physics PLE in Zimbabwe exclude aspects of IK and the background experiences of the teachers and learners in the policy, design and the appearance of buildings and classrooms. Furthermore, the teachers' pedagogy and physics content in classrooms are not culturally aligned and contextualized with IK as stipulated by the curriculum. Also, PLE particularly the school arena bears imprints of western ways of life with westernized produced artefacts, values and ways of doing things. Current PLE were designed in the context of Eurocentric-curricula and culture during colonialism and still prominently exists. For example, the laboratory buildings in schools are given English names of western scientists and in some cases the architectural designs of buildings in the schools still resemble Western dormitory or barracks architecture of bare buildings and an array of blocks. As a result, the PLE of schools often projects a disjuncture and a foreign environment with that of the colorful and symbolic huts and African homes and villages that learners are familiar with. Hence, the current PLE fail to stimulate a nuanced IK understanding and links to culturally relevant home experiences of the learners. The physical characteristics of PLE can affect learners in a subliminal way, affecting their emotions, with important cognitive and behavioural consequences [19]. This can result in physics teaching being abstract with the lack of their everyday experiences and hence difficult for learners, leading to poor performances and high dropout rates. Studies suggest that PLE should be closely connected to the needs of the learner, their culture, beliefs, activities, and prior knowledge and should also be complemented by culturally responsive teaching [20]. How to transform PLE and create IKS through integrating physics and indigenous knowledge is the problem this study sought to answer.

3. Literature

Definitions of Indigenous Knowledge

While the study preferred one definition of IK, there are several definitions in literature that can elucidate our understanding of IK. For example, Takawira [21] views IK as local knowledge, community based knowledge that exists uniquely in a given culture and evolves from one generation to another. Onwu and Mosimege [22] see IK as a variety of knowledge that covers technologies and practices that were used and are still being used by indigenous people for existence and survival in various situations and environments. Khupe [4] affirms that IK originates in oral cultures and abides in the hearts and minds of elders and specialists knowledge keepers in particular areas. These definitions indicate that IK is generally the knowledge generated, developed and used by people in a certain area. Generally, it involves all forms of knowledge – technologies, know-how, skills, artefacts, artefacts, art, beliefs, teaching and learning approaches etc. that enable the community to achieve stable livelihoods in their environments. It is handed down from one generation to another orally or via apprenticeship by those who hold it such as elders in the community as cited by Mawere [23]. The inclusion of IK in curricula can be both in content and context based [24].

Definitions of Learning Environments

Learning environments are defined in diverse ways so coming to a single definition is problematic due to the complex nature of interactions that occur in the learning environments and also the lack of consensus on the meaning and use of the phrase learning environment [25]. Learning environments are frequently used to refer to the sociological, conceptual, or psychological environment than to the physical spaces [12]. Learning environment is often defined as where the learning process takes place [26]. In addition, it is a place where learners may work together and support each other as they use a variety of tools and information resources in a guided pursuit of learning goals [25]. Learners also using tools and devices collect and interpret information and interact with others [27]. For the promotion of IK, a learning environment is a space - IKS where learners and teachers work together and engage in authentic activities; where they use a variety of IK artefacts as mediating tools, signs, symbols, rules and draw upon learning resources to make sense out of things and also construct meaningful understandings and develop skills relevant for solving problems.

Science and Physics PLE

Individuals need to view, touch, smell, produce solutions to problems, etc. so that they will be able to act like a scientist to understand and make sense of the phenomena occurring in the outer world [27]. Well-designed PLE should afford learners conditions that enable them to engage in these important scientific activities. PLE should be designed according to the strategy of inquiry-based learning so that learners can consolidate on what they learn in the classrooms while at the same time learn new knowledge meaningfully and permanently. The PLE should offer learners opportunity to have hands-on experiences by using most of their senses and organs [27]. It must offer learners opportunity for direct engagement with the subject content, real objects and environments. Research suggests that learning in familiar physical settings like a well-designed school yard, can result in greater engagement and science achievement for learners [28].

Learners can be taught informally by what appears in their PLE without much explanation. The PLE's built-in pedagogy would be a setting of what to learn or teach, how to learn or teach, and also how to act and respond. Built-in pedagogy is based on the belief that the cultural, psychological and behavioural attributes of PLE are linked to and embody specific pedagogical practices that can shape learners' learning experiences and behaviours [29,30].

The PLE may have stimulating physical properties that afford an individual the opportunity for a particular action. Educational architecture grounds itself in a conviction that the design of PLE influences the behaviours and actions of learners within those spaces [29]. For example, the existence of broken-down school truck in the school yard may afford a learner a chance to explore and learn informally from it. Gibson [31] named these 'action possibilities' which are latent in the environment as affordances or Gibsonian affordances. A well-trained eye can read the PLE for the pedagogies they facilitate [29]. What people see in the environment determines what the group of people classify and value as knowledge [32,33].What goes on in the laboratories contributes very little to the learning of science or to the learning about science and its methods, except memorized content and a few disconnected skills [32]. PLE enhance learners' achievements, develops scientific process skills, and positively affects attitudes and motivations [27,29]. Therefore, the state of the PLE in which the teaching and learning of physics is done should not be ignored in the IK integration agenda.

In the physics classrooms, some teachers in Southern Africa are integrating IK in their instructions as required by the new trends in science education [34]. This includes the use of IK artefacts as examples when explaining concepts and in demonstrations. For example, the use of bows and arrows to explain projectile motion and deadfall traps (mariva) can be used to explain the concepts of equilibrium and stability. The classroom activities are designed in such a way that they resemble the cultural home experiences and IK of the learners as required by the curriculum but there is a glaring absence of IK in the PLE. Only western equipment like test tubes, burettes, and electrostatic generators some of which were designed during the colonial education era are evident. This has resulted in a situation that while there is a new pedagogy of constructivist and decolonized emphasis on learning in the classrooms, the PLE have not changed.

4. Theoretical Framework

The study is grounded in the Social-Cultural Theory (SCT) and situated in a Postcolonial Framework. SCT is based on Vygotsky's 1978 seminal work emphasizes the importance of culture and context in constructing knowledge and enhancing meaningful learning. A socio-cultural approach in science is based on the understanding that humans involving in scientific activities take place in cultural contexts, mediated by cultural symbols [35]. SCT acknowledges the need for the designing and creation of an appropriate PLE where cultural resources are used as capital that can be used to guide, enrich, and support teaching and learning which the basis of this study is.

Postcolonial theory is a body of thought associated with post colonialism that emerged in the US and UK academia in the 1980s as part of a larger movement to combat the West's colonization and imperialism especially in India, Africa, Asia, and Latin America, and has been broadened to include a diversity of geographical, racial, and cultural contexts and histories [36]. It is primarily concerned with accounting for the political, aesthetic, economic, historical, and social impact of European colonial rule around the world in the 18th through the 20th century [36]. Postcolonial theory draws on critical theory to understand the loss of power, identity, and culture when a group of people are dominated by a conquering force [37]. The prefix 'post' of 'postcolonial theory' has been rigorously debated, but it has never implied that colonialism has ended; indeed, much of postcolonial theory is concerned with challenging the lingering forms of colonial authority after the formal end of the Empire [36]. Postcolonial theory therefore challenges the traditional sense of superiority demonstrated historically by Europe and the United States when encountering people of other countries and epistemology that fuels western philosophy, politics, education, and social-economic theory [37]. Postcolonial theory takes many different shapes and interventions, but all share a fundamental claim: that the world we inhabit is impossible to understand except in relationship to the history of imperialism and colonial rule [36]. A postcolonial framework helps researchers and educational practitioners to avoid reproducing injustices and stereotypes, illuminate the complexities of life at the intersections, and contribute to the construction of a more socially just world [38]. Despite frequent critiques from outside the field (as well as from within it), postcolonial theory remains one of the key forms of critical humanistic interrogation in both academia and globally [36]. It remains a major methodological tool with which to trace the patterns of epistemological and pedagogical reterritorialisation of the non-Western world [39].

Like the science curriculum and its associated classroom pedagogy in Zimbabwe, the PLE have undergone stages of colonization, neo-colonization, and currently undergoing decolonization. Military conquests and socio-economic domination of African societies by the western powers led to the imposition of the PLE designed, constructed and validated by colonialists and suitable for their colonial curricula content and pedagogy. Since the factors that drive the designing of PLE have changed due to political changes, it is imperative that the traditional learning environments should also change. There should be a resuscitation of African values, ways of knowing, science, and technology in the PLE.

The following research questions pertain to this study.

1. What are the artefacts and resources present in physics and how is it used in the current Physical Learning Environments in schools in Zimbabwe?
2. What are the views of physics teachers in Zimbabwe on the creation of indigenous knowledge spaces in Physical Learning Environments?
3. How can indigenous knowledge spaces be created in physics Physical Learning Environments, explored from a postcolonial perspective?

5. Research Methodology

The case study involved physics teachers' knowledge about creating indigenous spaces in physics Physical Learning Environments (PLE). Purposive and convenience sampling techniques were employed in the selection of eight high schools from which twenty physics teachers who participated in the study were selected. Physics teachers with indigenous experiences were considered as a valuable source of information to make judgments about PLE as they have encountered many different indigenous environments and have interacted with formal science learning environments for a long time. They also learnt about science PLE in the science education courses during training therefore they were seen as in an ideal position to project a transformative image of both the current state of the science PLE and an IK transformed PLE. Educational research can be problematic [40], subject to differing interpretations of whether practitioners should be involved and indeed to what extent. In this study, physics teachers were considered for the study [41] since their views are important when it comes to educational reforms as they are agents of change who can generate contextualized knowledge and accelerate the decolonization agenda and restorative justice.

Data were collected quantitatively from a Likert-scale questionnaire from 20 teachers and qualitatively from observations and interviews. The instruments allowed the teachers to express their views on the creation of the indigenous PLE and to give examples on how this could be done, including expected challenges and solutions in a postcolonial era. The questionnaires had a section that contained items with statements to which teachers had to respond to a Likert-scale indicating the extent to which they agreed or disagreed with the statements. For example, do they agree/disagree to 'the creation of IK space in the PLE? The focus group interviews conducted were semi-structured with the larger part having more flexible worded questions that were drawn from the findings of the questionnaire. Site visits were also conducted at the eight high schools to observe and identify evidence of IK in the PLE. The number of data gathering methods triangulated the study as all three data sources were used together in the analysis and categorization of items situated in their PLE. In the analysis, frequency tables were developed for items from the questionnaire to identify the trends and patterns in some of the responses. All the focus group interviews were transcribed verbatim and checked with the teachers for accuracy of the interview transcript data. The interviews were analyzed via content analysis. Firstly, key constructs of resources like 'composite charts and posters' were identified from the transcriptions of interview data. Secondly, the relevant transcripts corresponding to the key constructs were matched to substantiate as evidence of the key constructs. Observation notes were also analyzed via content analysis. The findings were also discussed with teachers to confirm or refute the findings and solicit for further clarification. Their participation and feedback were acknowledged. Pseudonyms were used in the findings and discussions to ensure confidentiality of participants.

6. Data Analysis and Results

i) Observational evidence of artefacts in Physical Learning Environments (PLE) associated with Science/Physics

The samples of items associated with the learning of physics in high schools that were observed by the researcher during school site visits in the PLE and also elaborated by teachers in questionnaire and interviews are tabulated in Table 1.

Table 1. Physical Learning Environment artefacts associated with Science/Physics

Features/Artefacts/Artifacts	Origin	Current use at the school where it was observed
Broken down tractor	Was used for Agricultural activities	Teacher used it to demonstrate concept of air pressure, pressure, and surface area using its wide wheels, and pneumatics.
Old and broken laboratory equipment in the school (scales, solar panels, electric plugs, overhead projectors)	School laboratory	Teaching about safety in the laboratories and the internal components of overhead projectors such as light bulb and lenses, conversion of energy (solar panel).
Broken down truck	School truck	Learners were observed imitating driving to develop mechanical skills and observational skills, notion of speed by changing gears and rotational motion (rotation of wheel).
Old and broken laboratory equipment in the school (scales, solar panels, electric plugs, overhead projectors)	School laboratory	Teaching about safety in the laboratories and the internal components of overhead projectors such as light bulb and lenses, conversion of energy (solar panel).
Old engine block	Old school truck	Learners normally imitate the movement of pistons in the block learning about force, pressure etc.
Disused garage (with rusty spanners and car parts)	Constructed before independence of Zimbabwe	Learners used to play in the garage during free time. Learning now about torque (spanner), electricity (bulb and wires), chemical erosion (rust) etc.
Old solar geysers	Installed during colonialism	Teachers used to refer to them when teaching topic on Energy showing thermostats, copper piping for conduction and insulation materials.
Structures and creative architecture e.g. modern library building	Designed and built before independence	Teacher refers to it as an example when teaching concepts on structures, force, pressure, materials.
School buildings given English names e.g. EUREKA block in one of the schools	Named by colonialists before independence	Learners become familiar with famous historical scientists names and stories as they associate with Archimedes and why Eureka! and learn about Archimedes Principle of fluid displacement.
Billboards with a pictures of a tractor near the school garden and classrooms	Placed by the school's agriculture department	Teachers sometimes ask learners to identify parts of the tractor on the billboard.

The identified artefacts were placed in the PLE, although not originally intended to be used as pedagogical tools but the findings indicate that the learners and the teachers interact with them and use them as pedagogical tools in both formal and informal contexts. These aids complement classroom instruction as learners make associations with a concept and the artefacts. There were no prominent indigenous artefacts such as clay pots in the PLE to connect with the IK aspects. The researcher observed that there were no indigenous artefacts in the high schools PLE, on the fields or in the classrooms and evident in Table 1. For the Zimbabwean curriculum that claims that the ZIMSEC Advanced Level physics syllabus must value IK and integrate it with content and pedagogy, the current PLE reflects poorly on these valuable local resources for teaching and learning.

ii) Physics teachers views on creating IK spaces in the PLE

The questionnaire given to teacher to complete sought their views on the creation of IK spaces to enhance their PLE. Table 2 provides the frequency distribution for selected questions on IK spaces.

The results of the analysis of the quantitative data collected from the questionnaire in table 2 indicate that 90% of teachers see the creation of IK space as necessary and possible with 5% of them being uncertain and another 5% disagreeing. The results show that most teachers believe that having an IK space in their PLE will make physics more contextualized to their backgrounds.

Table 2. Frequency distribution for selected questions of the creating of IK spaces

Questionnaire Item	SA	AG	DA	SDA	Uncertain
Creation of IK space in the PLE is necessary	16 (80%)	2 (10%)	1 (5%)	-	1(5%)
Currently there are no IK spaces in PLE	16 (80%)	2 (10%)	2 (10%)	-	-
Having IK in PLE makes physics more relevant	18 (90%)	1 (5%)	1 (5%)	-	-

iii) PLE designs that emerged from Physics teachers' responses

Teachers in their responses to the third research question of creating indigenous spaces in physics PLE proposed local indigenous pedagogical innovations and initiatives that complement physics instructions. These initiatives and the reactions of participants for a post-colonial era are summarized in Table 3 below.

Table 3. Frequency responses from physics teachers on postcolonial Physical Learning Environments

Design Elements	SA	AG	DA	SDA	Uncertain
Integrated physics laboratory	15 (75%)	5 (25%)	-	-	-
Model traditional homestead	16 (80%)	4 (20%)	-	-	-
SimVillages	8 (40%)	12 (60%)	-	-	-
Mobile Posters	17 (85%)	3 (15%)	-	-	-
Indigenous languages, terms and names	16 (80%)	4 (20%)	-	-	-
Designs of buildings	14 (70%)	5 (25%)	-	-	1 (5%)
Realia	19 (95%)	1 (5%)	-	-	-
Task managers	19 (95%)	1 (5%)	-	-	-
Composite charts	15 (75%)	5 (25%)	-	-	-
Integrated science museum	15 (75%)	5 (25%)	-	-	-

The results indicate that 95% of the teachers see the need for the creation of IK space in the physics PLE. The majority of teachers supported the idea of creating postcolonial IK spaces through initiatives indicated in Table 3 with only about 5% of the teachers indicating some reservations.

7. Discussion

7.1. Assertions from the Study

The results on creating IK space in the physics PLE from the analysis of the data collected from the questionnaires were compared with the common themes emerging from the interviews and observations and resulted in the generation of assertions which are reported as follows.

Assertion 1: Teachers maintain that the creation of IK space supports learning of physics by making it more relevant.

The twenty teachers in the sample indicated that there is need for the creation of IKS in the PLE and gave varied reasons. This shows an overwhelming support for the creation of this indigenous space by the physics teachers. The result is supported by the following excerpts from the interviews. The interviewer asked, whether creation of space for IK in PLE is important and the teachers responded.

Tomu: *It creates heighten awareness, stimulates new thoughts, and generates discussions on scientific concepts inherent in the IKS and IK artefacts in the environment.*

Gumbo: *It develops pride in one's environment.*

Moyo: *IK becomes a resource for learning and a valuable instructional tool.*

The views of teachers agree with Michie and Linkson [42] and Mothwa [43] who assert that IK has been recognized as a valuable teaching resource. Teacher Tomu spoke about IKS as significant for generating creativity. Teachers were of the view that PLE will stimulate learners and teachers to be curious, creative, and to critically think about and discuss how to solve complex and relevant societal and economic problems [29]. As IK is contained in local environment, the PLE become a key resource both for teachers and learners who need concrete examples to draw on. It is also a valuable resource for teachers who do have a rich background in IK and who do not know how IK can be integrated into their instruction. However, Naidoo [44] adds that while IK exists in the environment, it is not well documented and not readily available to teachers to incorporate into their lessons. Even the current African textbooks lack reference to IKS and IK artefacts.

Assertion 2: Some teachers believe that there is no space for IK in the physical learning environments.

Their responses are captured in the following interview snippets.

Mogo: *We cannot have junk being brought to schools for the purposes of teaching and learning. Our syllabuses do not acknowledge that junk.*

Badza: *Unless our syllabuses are changed so that they include the indigenous artefacts that should be taught, we will not be teaching actual physics but junk physics.*

This strong view against creation of the IKS is underlined by the statistics that only two out of twenty teachers disagreed with interviewer as shown in Table 2 above. Their responses also agree with what was observed by Ogunniyi [45] and Webb [46] in their studies that some teachers felt that there is no space for IK and IK artefacts in the science classroom as they are not physics and should not be included in the formal curriculum.

7.2. Teachers' Suggestions of Design Elements in Enhancing the PLE

Ten PLE design elements are reported by teachers and are outlined in Table 3 and supported with data from teachers' interviews. The design elements are:

7.2.1. Integrated Physics Laboratories (IPL)

The creation of IPL was implied in teachers' responses and is reflected in the following excerpts. Shumba stated: *Schools should be encouraged to establish laboratories in which relevant authentic IK artefacts, their models and conventional apparatus may be kept together as it is now hard to find in the environment.*

Moyo added that: *Keeping IK artefacts e.g. claypots, bows, and arrows together with conventional apparatus like flasks, burettes, and test tubes would avoid seeing western apparatus as superior to indigenous ones.*

The teachers also argue that the creation of IPL will enhance the preservation and conservation of IKS and IK artefacts for use by future generations. In addition, if IK artefacts are in IPL, they will be viewed as important for teaching and learning.

7.2.2. Model Traditional Homestead (MTH)

The establishment of MTH in the PLE like the one in Figure 1 was implied in the following excerpts from Teacher Moyo:

A MTH with indigenous settings, traditional huts, and indigenous artefacts should be established on the schools' premises as a way of creating PLE. The design features of the hut can also be used to teach physics concepts e.g., stability and center of mass.

Figure 1. Traditional hut [From author' field notes]

Besides large-scale MTH that can be developed together with the community and school on school premises, a number of concepts and technical skills can be learnt. These include concepts like equilibrium, center of mass and heat transfer processes like conduction and convection.

7.2.3. SimVillages

The establishment of what we label as 'SimVillages' also emerged as one of the strategies for creating IK space in the PLE. This idea came out after the teachers realized that schools have limited time and resources to establish a traditional homestead village and to visit communities for lessons and practical activities with IK artefacts. They advocated for the creation of simulations of real-traditional villages for the learners and teachers to observe and teach local traditions and IK and science. These included games, dances, and creative-expressive indigenous artifacts and cultural activities like making fire from friction and building technology. Also traditional crafts like weaving, cooking, sewing, and pottery can be incorporated.

SimVillages provide a powerful alternative means of experiencing a society that is relevant to the learners' lived experiences and can also allow virtual field trips into exploring the indigenous community's lifestyles. Teacher Tembo added*: Also videos using the latest technology can provide opportunity for 3D virtual learning environments shown in media rooms.* Virtual field trips allow learners to explore their indigenous communities from the comfort of their schools. They eliminate the need for transportation, decrease lost instruction time spent on travel, and involve fewer safety concerns. Videos of SimVillages and IK activities may be posted on online learning spaces like Google classrooms and science teaching portals to connect to the virtual world. Also, using ICT especially during the COVID pandemic is a safe way for teaching.

7.2.4. Indigenous Languages, names, and terms

The use of indigenous names and terms to label items in the school environment has also been identified as a way of creating space for IK in the PLE. Observations indicate that, ccurrently some school buildings have names of Western scientists. Teacher Tembo adds: *Teachers should use indigenous languages for names and terms in the school environment, for example, Jerero for library and Chinu for a bottle of indigenous made oil. They can also use names of famous IK practioners or elders like sekuru Kaguvi.*

Teachers' view agrees with views from literature that one's indigenous language must be integrated in the school curriculum [47]. The daily use of indigenous languages allows the learners to assimilate information faster and think creatively rather than the foreign language imposed for learning and teaching [48]. Shizha [47] posits that learners taught in their home language perform better than those taught in English. Thomson [49], in studying Keiyo (Kenya) science affirmed that there are sciences and similar science words in people' languages which educators need to unravel. While in some instances, the indigenous terms to refer to the same word used and can be confusing to a non-native speaker, for example, both force and power are referred to as 'Amandla' or 'Simba' but in physics they are different concepts [50]. In such cases, Dei and Simmons [51] suggest that both the use of western and indigenous languages should be encouraged, described as language integration in an educational inclusive practice. Even a created word in local language may also be coined in consultation with the elders in the production of a local science dictionary that will enhance acquisition of scientific concepts.

7.2.5. Large posters or mass media

The use of large and catchy mobilization posters or mass media was also proposed by teachers as another way the IK space can be created in the PLE. Teacher Tarubva elaborates: *Posters or mass media with a balanced mixture of pictures of both IK and western IK related* to *physics concepts should be mounted in the school premises. These have the effect of drawing attention of learners and develop a positive attitude towards learning.*

Despite the fact that poster presentations are broadly favoured in scientific conferences, they are now being utilized as a teaching tool in numerous fields of study [52,53,54]. Posters and now in digital formats too are becoming important and a stimulating teaching tool that is attractive and colorful that enriches the PLE visually [55]. Posters promote unintentional learning and effortless collaborative learning hence they are inspiring and facilitate holistic and synthesized meaningful learning [52,55].

7.2.6. Design of buildings

Teachers proposed that schools should adopt architectural designs of buildings that resemble IK and IK artefacts. Teacher Dafi comments: *Schools should adopt designs of buildings that resemble IK and IK artefacts so that the built environment can prompt learners to be curious.*

Buildings should have the ability to meet the learner' wide range of needs, both now and future [17,56]. If the schools cannot afford to have such structures, then learners can be given projects in design and structures and given a chance to interrogate some design features including IK and IK artefacts as part of their learning.

7.2.7. Realia (objects from real life)

The use of realia was also among the strategies suggested for creating IK space in the PLE as indicated by teacher Guyo: Pieces of authentic objects from real life that intersect with physics concepts should be placed in Phenomenaria like aquariums, SimCity and Physics micro worlds. The community can contribute as it will be a safe and active museum for their cultural and historical artefacts.

These interactive museums and phenomenaria allow for new knowledge to be created by constant interaction with the environment [57]. Phenomenaria are areas for the specific purpose of presenting phenomena and making them accessible to scrutiny and manipulation [58]. Microworlds describe digital media designed to facilitate communication between researchers, technicians, teachers and students as they become engaged in changing them [59]. The idea of microworlds is underlain by the constructivist epistemology [60]. Physics microworlds are also known as participatory simulations [61] and computer based manipulatives [62,63,64] and are much smaller collection of instructional software based on the principle of invention, play and discovery [65]. The thrust is to give the learners resources to build and refine their own knowledge in personal and meaningful ways. Realia are also different from other educational instructional softwares that are based on the paradigm of 'explain, practice, and test' and are normally confused with computer-bases simulations [65]. Using realia will set the tone for user interactions and relationships and will allow learning to be embedded in realistic and relevant contexts.

7.2.8. Guides

Teachers proposed the assigning of community instructors with multidisciplinary knowledge and skills, ideally chosen from the local communities that set tasks and provide guidance, feedback, active hands-on learning tasks. Teacher Gumbo elaborates: *There are knowledgeable and skilled elders and guides with talents so they can assist learners and teachers in local language too.*

The instructors will use traditional ecological knowledge (TEK) to help to convey cultural knowledge and skills to learners and teachers in the PLE so that authentic contexts of the tasks are engaged in. For example, the making of an artifact (e.g. bow and arrow) from the field to use in the classroom that includes safety and conservation practices.

7.2.9. Composite charts and posters

Teachers also proposed the use of charts and posters with a balanced integration of IK and western IK ideas. Teacher Moto proposed that: *Teachers should display* charts *that show painted pictures or models of IK artefacts like reed mats made by the local people or in classrooms and hung down classroom verandah walls or trees in the school yard. The posters and learning charts should also be colorful and, informative.*

Teacher Shuro added: *The composite charts and posters can be captured and filed digitally and uploaded on learning management system tool such as Canvas, Google classroom for archival purposes.*

The excerpt indicates the use of educational charts or posters which can be physical (e.g. using traditional handmade cardboard) and digitalized so as another way of increasing interaction of the learners with the IK artifacts.

Poster media of IK was seen to be relevant and appropriate to improve the quality of learning and students' achievement in countries with indigenous populations as in Indonesia [55]. Posters provide an opportunity to pair visual learning with textbook reading, lesson, and traditional homework assignments. One of the indicators of successful learning and quality improvement is indicated by the teacher's ability in utilizing learning media, for instance attractive posters based on the subject matter for creating effective learning contexts [66].

7.2.10. Integrated IK-science-physics museums

The establishment of integrated IK-science-physics museums with a balanced mixture of IK and western IK tools and crafts in the PLE was supported by teachers. Teacher Gomba added*: Museums with a balanced mixture of IK and western tools and crafts should be established. These may include mariva (deadfalls), zvireyi (sledges) and miseve (arrows) which have some physics mechanics concepts associated with them.*

The design elements indicated in the data seem to suggest establishment of an environment similar to free-choice learning environment or modern science public interactive venues. These are voluntary settings usually in consideration of the local social environments and designed considering the needs and interests of the learners in supporting free-choice learning [27]. In the context of these findings, the locally developed IK artefacts and design elements would arouse and sustain the learning and IK integration among the teachers and learners if housed in a museum at school or in a cluster of schools. They will allow learners to apply and develop some indigenous and science process skills like observation, predicting, drawing and making inferences [67]. These may also cause perceptual shifts amongst teachers and learners from construing physics or science and IK as polar opposites, to considering the two thought systems as compatible and complementary.

7.3. Teachers' Concerns about IK-Science Integration in PLE

Although the teachers generally agreed that creation IK-PLE is necessary and possible, they were worried about the availability of IK and IK artefact in the communities to be collected and be made available in the learning environments. Teacher Mago expresses his concern*: IK and IK artefacts are fast disappearing from our communities because of neocolonialism, modernization, and stigmatization and we will require these to be donated to the school museums. Some will want to be paid for these and so there is a financial cost. Who will pay?*

However, teacher Gudo added a contradictory view: *If we concentrate on using IK and IK artefacts, we will be accused of diluting school physics and presenting pseudo physics to learners.*

The dominance of western and the glaring absence of indigenous artefacts in the PLE associated with the learning of physics confirm that PLE are still colonized and divorced from culturally aligned classroom instruction. Hence, the need for PLE to be decolonized and contextualized but the practical question is on how to modify the current PLE as there are cost and resource implications. The benefits of design elements of PLE as suggested by the teachers (Table 3) are that its physical characteristics can affect learners emotionally, with important cognitive and positive behavioural consequences [19]. The current design of PLE for teaching physics means it is often taught in an abstract and decontextualized environment using a foreign language. This often leads to poor performance, negative attitudes, and high dropout rates among the learners. Teachers in this study are of the view that if PLE are transformed in that it complements classroom pedagogy that mirrors and provides a decolonized and empowering image for indigenous learners, then it would enhance their perceptions of physics as relevant to their daily indigenous lives.

8. Conclusions

The study sought to explore the creation of IK space in the physics Physical Learning Environments (PLE) based on observations, views and insights from physics teachers. This study emphasizes the need to organize the PLE around the culture and home experiences of the learners. This emanated after the realization that the teachers were integrating IK and IK artefacts in their classroom physics instruction while the physics PLE are dominated by western pedagogical features that do not have IK and IK artefacts imprints. The findings indicate that the creation of IK teaching and learning spaces in the PLE is possible and necessary as it supports and complements instruction with a cultural contribution in transforming a postcolonial society. The PLE also provides natural spaces within which scientific concepts can be linked to the IK artefacts present in the environment. Teachers proposed the establishment of integrated laboratories, model traditional homestead, SimVillages, indigenous names for school buildings, composite museums, composite charts, architectural designs of buildings etc. that integrates IK and IK artefacts, promoted by locally trained community guides. The study highlights the need for teachers to reflect on their present colonized teaching and learning environments with a view of transforming to a postcolonial culturally aligned IK-Physics integrated classroom instruction.

9. Recommendations

In Physics teaching, PLE should be designed and constructed integrated with IK with choices being made at institutional, school and community level. The community would act as a reservoir of the IK artefacts. It is recommended that collaborative and synchronous learning activities can lead to more contextualized learning taking place more outside of the classroom time than before [68].

10. Implications

In post-colonial societies, both western knowledge and African IK together with their associated artefacts should be given the same value in education. The teaching and learning of physics, if locally contextualized, would enhance the linking of concepts. This may lead to increased interest, positive attitude and improved scientific literacy that is required for socio-economic development among indigenous communities and beyond.

REFERENCES

[1] McCausland J.D, "Learning “real” science: Storying whiteness in university science labs," Journal of Curriculum and Pedagogy, pp. 1-24, 2020. https://doi.org/10.1080/15505170.2020.1845883.

[2] Warren D.M., B. Rajasekaran, "Putting local knowledge to good use," International Agricultural Development, vol.13, no.4, pp.8-10, 1993.

[3] Cull, I., Biin, D., Simcoe, J., Erickson, M., Hancock, R. L. A., McKeown, S., A. Vedan, "Pulling together: A guide for front-line staff, student services, and advisors," 2018.

[4] Khupe C, "Indigenous knowledge and school science: Possibilities for integration, in Faculty of Science, School of Science Education," University of the Witwatersrand, 2014.

[5] Mukwambo M., Ngcoza K., C. Chikunda, "Africanisation, Ubuntu and IKS: A learner centred approach Schooling, society and inclusive education," In C. Okeke, M. van Wyk, & N. Phasa (Eds.), Schooling, society and inclusive education: An African perspective, Cape Town, South Africa: Oxford University Press, pp. 65–80, 2014.

[6] Baquete A.M., Grayson D., I.V. Mutimucuio, "An exploration of Indigenous knowledge related to physics concepts held by senior citizens in Chókwé, Mozambique," International Journal of Science Education, vol.38, no.1, pp.1-16, 2016. DOI: 10.1080/09500693.2015.111513.

[7] Aiyelabegan A. T. "Effect of physics practical on Students' Academic performance in Senior School Certificate Physics Examination in kwara state. Lafiagi," Journal of Science Education, Vol.5, no.1, pp. 84-89, 2003.

[8] Aina, J. K, "Subject Area Specialization-Combination Correlation in Colleges of Education: Effect on Students' Achievement in Physics," Open Journal of Education, Vol. 1, no.3, pp.113-116, 2013. DOI: 10.12966/oje.06.06.

[9] McLoughlin, C., & Oliver, R, "Designing learning environments for cultural inclusivity: A case study of indigenous online learning at tertiary level," Australasian Journal of Educational Technology, vol.16, no.1, 2000. DOI: https://doi.org/10.14742/ajet.1822.

[10] Aldridge J. M., Fraser B. J., Bell L., J. Dorman, "Using a new learning environment questionnaire for reflection in teacher action research," Journal of Science Teacher Education, vol.23, no.3, pp. 259-290, 2012.

[11] Walker S.L., B.J. Fraser, "Development and validation of an instrument for assessing distance education learning environments in higher education: The Distance Education Learning Environments Survey (DELES)," Learning environments Research, vol.8, no.3, pp. 289-308, 2020. DOI: 10.1007/s10984-005-1568-3.

[12] Cleveland B., K. Fisher, "The evaluation of physical learning environments: A critical review of the literature," Learning Environments Research, vol.17, no.1, pp.1-28, 2014. DOI 10.1007/s10984-013-9149-3.

[13] Ibrahim N., N. Fadzil, "Informal setting for learning on campus: Usage and preference," Procedia-Social and Behavioral Sciences, vol.105, pp. 344-351, 2013. DOI: 10.1016/j.sbspro.2013.11.036.

[14] Strange, C. C., J.H. Banning, "Educating by Design: Creating Campus Learning Environments That Work," Jossey-Bass, San Francisco: ERIC, 2021.

[15] Doppelt Y., Mehalik M. M., Schunn C. D., Silk E., D. Krysinski, "Engagement and achievements: A case study of design-based learning in a science context," Journal of Technology Education, vol.19, no2, pp.22-39, 2008.

[16] Flavier, J.M., A. de Jesus., S. Mavarirro, "The regional program for the promotion of indigenous knowledge in Asia (REPPIKA)," In D. M. Warren, L. J. Slikkerveer, & D. Brokensha (Eds.),The cultural dimension of development: Indigenous knowledge systems, London, Intermediate Technology Publications, pp. 479–487, 1995.

[17] Oblinger, D. G. (Ed.) "Learning spaces. Boulder," CO: Educause, 2006. https://www.educause.edu/research - andpublications/books/learning - spaces (accessed May2021)

[18] Mapara J, "Indigenous Knowledge systems in Zimbabwe: Juxtaposing Post Colonial Theory," The Journal of Pan African Studies, vol.3, no.1, pp. 139-155, 2009.

[19] Sandeep P, "How We Create Effective Teaching-Learning Environment," International Journal of Education and Psychological Research, vol.2, no.3, pp.8-12, 2013.

[20] Prawat R.S, "Teachers' beliefs about teaching and learning: A constructivist perspective," American Journal of Education, vol.100, no.3, pp. 354-395, 1992. DOI: 10.1086/444021.

[21] Takawira M. D, "The role of public participation in environmental management: a criticalexamination of grassroots participation in decision-making in environmental management", unpublished LL.B dissertation, University of Zimbabwe, 2000.

[22] Onwu G., M. Mosimege,"Indigenous knowledge systems and science and technology education: A dialogue," African Journal of Research in Mathematics, Science and Technology Education, vol.1, no.8, pp.1-12, 2004.

[23] Mawere V.H, "Culture, Indigenous Knowledge and Development in Africa: Reviving interconnections for sustainable development," Langaa RPCIG Pub., 2014.

[24] Moji C., A. Hattingh, "A relevant physics curriculum: tapping indigenous African knowledge systems," Indilinga African Journal of Indigenous Knowledge Systems, vol.7, no.2, pp. 223-236, 2008.

[25] Duffy T. M., Lowyck, J., Jonassen, D. H., T.M. Welsh,

"Designing environments for constructive learning," Springer, 1993.

[26] Richardson C., P. Mishra, "Learning environments that support student creativity: Developing the SCALE," Thinking Skills and Creativity, vol.27, pp.45-54, 2018. https://doi.org/10.1016/j.tsc.2017.11.004.

[27] ASLAN A, G. DEMİRCİOĞLU, "A review on Turkish graduate studies performed on out-of-school learning environments," Karadeniz Teknik Üniversitesi Sosyal Bilimler Enstitüsü Sosyal Bilimler Dergisi, vol.8, no.16, pp. 379-402, 2018.

[28] Zion M., I. Sadeh, "Curiosity and open inquiry learning," Journal of Biological Education, vol.41, no.4, pp.162-169, 2007.

[29] Monahan T, "Flexible space & built pedagogy: Emerging IT embodiments," Inventio, vol.4, no.1, pp. 1-19, 2002.

[30] Puteh M., Che Ahmad C. N., Mohamed Noh N., Adnan M., M.H. Ibrahim, "The classroom physical environment and its relation to teaching and learning comfort level," International Journal of Social Science and Humanity, vol.5, no.3, pp.237-240, 2015. DOI:10.7763/IJSSH.2015.V5.460.

[31] Gibson J.J, "The ecological approach to visual perception: classic edition," New York, Psychology Press, 2015. DOI: https://doi.org/10.4324/9781315740218.

[32] Osborne J., J. Dillon, "Good practice in science teaching: What research has to say: What research has to say", UK, McGraw-Hill Education, 2010.

[33] Ezeanya-Esiobu C. "Indigenous Knowledge and Curriculum in Africa. In: Indigenous Knowledge and Education in Africa," Frontiers in African Business Research, Singapore, Springer, 2019. https://doi.org/10.1007/978-981-13-6635-2_1.

[34] ZIMSEC, "Zimbabwe school Examination Council (ZIMSEC) Advanced Level Physics: Syllabus 6032), Examination syllabus for 2015 - 2022," Mount Pleasant, Harare: Curriculum Development and Technical Services, 2015.

[35] John-S V, H. Mahn, "Sociocultural approaches to learning and development: A Vygotskian framework." Educational Psychologist, vol.31, no.3-4, pp.191-206, 1996. https://doi.org/10.1080/00461520.1996.9653266

[36] Elam, J.D, "Postcolonial theory". In Literary and critical theory. Oxford University Press, 2019. https://doi.org/10.1093/obo/9780190221911-0069.

[37] Khanal N, "The lens of postcolonial theory in LIS research and practice," Doctor of Philosophy in Library & Information Science," University of Illinois at Urbana-Champaign, 2012.

[38] Mohammed S.A, "Moving beyond the “exotic”: applying postcolonial theory in health research," Advances in Nursing Science, vol.29, no.2, pp.98-109, 2006.

[39] Roy A, "Postcolonial theory and law: A critical introduction," Adelaide Law Review, Vol. 29, no.2, pp.315-57, 2008. https://search.informit.org/doi/10.3316/agispt.20091776.

[40] Stenhouse L, "What counts as research?," British Journal of Educational Studies,Vol.29, no.2, pp. 103-114, 1981.

[41] Elliott J, "Making evidence‐based practice educational," British Educational Research Journal, Vol. 27, no.5, pp.555-574, 2001.

[42] Michie M., M. Linkson, "Interfacing Western Science and indigenous knowledge: A Northern Territory perspective. The 30th Australasian Science Education Research Association Conference, Rotorua, Aotearoa New Zealand, Jul., 1999, pp.12-14.

[43] Mothwa M.M, "Teachers’ experiences of incorporating indigenous knowledge in the life sciences classroom," Doctoral dissertation, Johannesburg, University of Johannesburg, 2011.

[44] Naidoo P.D, "Teachers’ interpretation and implementation of the policy on Indigenous Knowledge in the science national curriculum statement," PhD thesis, University of KwaZulu-Natal, 2010.

[45] Ogunniyi M. B, "The challenge of preparing and equipping science teachers in higher education to integrate scientific and indigenous knowledge systems for their learners," South African Journal of Higher Education,Vol.18, 3, pp 289-304, 2004.

[46] Webb P, "Indigenous knowledge and science education: What knowledge, whose knowledge and how do we bridge the gap?," In V. Msila, & M.T. Gumbo (Eds.), Africanising the Curriculum: Indigenous Perspective and Theories, South Africa, SUN MeDIA, pp.177-194, 2016. DOI:10.18820/9780992236083

[47] Shizha E. "Reclaiming our memories: The education dilemma in postcolonial African school curricula," In Issues in African Education, New York, Palgrave Macmillan, pp. 65-83, 2005.

[48] Cronje A., de Beer J, P. Ankiewicz, "The development and the use of an instrument to investigate science teachers' views on indigenous knowledge," African Journal of Research in Mathematics, Science and Technology Education, vol.19, no.3, pp.319-332, 2015. https://doi.org/10.1080/10288457.2015.1108567

[49] Thomson N, "Science education researchers as orthographers: documenting Keiyo (Kenya) knowledge, learning and narratives about snakes," International Journal of Science Education, vol.1, no.25, pp.89-115, 2003.

[50] Dlodlo T.S, "Science Nomenclature in Africa: Physics in Nguni," Journal of Science Teaching, vol. 36, no.3, pp. 321-331, 1999. https://doi.org/10.1002/(SICI)1098-2736(199903)36:3<321::AID-TEA6>3.0.CO;2-8.

[51] Dei G.J.S, M. Simmons, "The indigenous as a site of decolonizing knowledge for conventional development and the link with education: The African case," In J. Langdon (Ed.), Indigenous knowledges, development and education, Rotterdam, Brill Sense, 2009, pp. 15-36.

[52] Dostál P, "Educational Effectivity of Posters in Technical Education of Secondary School Pupils," Journal of Technology and Information Education, vol.12, no.1, pp.27-37, 2020. http://www.jtie.upol.cz/pdfs/jti/2020/01/03.pdf.

[53] Otzurk O, "Using poster presentations to facilitate preservice EFL teacher learning," International Journal of Language Academy, vol.5, no.4, pp. 401-15, 2017.

[54] Pujasari R.S, "Undergraduate EFL Student's Experience. Script Journal," Journal of Linguistics and English Teaching, vol.4, no.1, pp. 51-61, 2019.

[55] Rosanti S.Y, N.A. Abu Seman, "The Effectiveness of Posters as a Learning Media to Improve Student Learning Quality," The Journal of Social Sciences Research, vol.5, no.4, pp.1046-1052, 2019.

[56] Hill J, "Spaces for Learning", World Architects, pp.1–19, 2013. Available at: http://www.worldarchitects.com/pages/insight/spaces-for-learning.

[57] Wilson B.G, "Metaphors for instruction: Why we talk about learning environments," Educational Technology, vol.35, no.5, pp.25-25, 1995. Available at https://www.jstor.org/stable/44428295.

[58] O'Donnell F, B. Tangney, "Towards' Phenomenaria' in the teaching of distributed systems concepts," The Third Proceedings of IEEE International Conference on Advanced Technologies, 2003, pp. 256-257.

[59] Kynigos C, "Half-baked logo microworlds as boundary objects in integrated design," Informatics in Education-An International Journal, vol.6, no2, pp.335-359, 2007.

[60] Jonassen D.H, "Objectivism versus constructivism: Do we need a new philosophical paradigm?," Educational Technology Research and Development, vol.39, no.3, pp.5-14, 1991.

[61] Wilensky U,N. Orleans, "Participatory Simulations: Envisioning the networked classroom as a way to support systems learning for all," Annual meeting of the American Research Education Association, New Orleans, LA, April, 2002. https://ccl.northwestern.edu/2002/ps-aera.pdf.

[62] Bouck E.C., L.A. Mathews, C. Peltier, "Virtual manipulatives: A tool to support access and achievement with middle school students with disabilities," Journal of Special Education Technology, vol.35, no.1, pp.51-59, 2020.

[63] Zacharia Z.C, C.P. Constantinou, "Comparing the influence of physical and virtual manipulatives in the context of the Physics by Inquiry curriculum: The case of undergraduate students' conceptual understanding of heat and temperature," American Journal of Physics, vol.76, no.4, pp.425-430, 2008.

[64] Nikiforidou Z, "Probabilities and Preschoolers: Do Tangible Versus Virtual Manipulatives, Sample Space, and Repetition Matter?," Early Childhood Education Journal, vol.47, no.6, pp.769-777, 2019.

[65] Rieber L.P, "Multimedia learning in games, simulations, and microworlds," In Mayer, R., & Mayer, R. E. (Eds.). The Cambridge handbook of multimedia learning. California, Cambridge University Press, pp.549-567, 2005.

[66] Harsono S.A., Syah M.F.J, N.I. Yantika, "Effect Of Teacher Training And Level Of Education On The Quality Of Learning in PROFUNEDU 2019," Proceedings of the 4th Progressive and Fun Education International Conference, Makassar, Indonesia. 6-8 August 2019, pp.1-8. https://eudl.eu/pdf/10.4108/eai.7-8-2019.2288437.

[67] Govender N, "Locating the Centrality of African Languages and African Indigenous Knowledge in the Embodiment Thesis: Implications for Education," Studies of Tribes and Tribals, vol.14, no.2, pp. 68-79, 2016. https://doi.org/10.1080/0972639X.2016.11886734.

[68] Brown M.B, J.K. Lippincott, "Learning spaces: more than meets the eye," EDUCAUSE quarterly, vol.26, no.1, pp.14-17, 2003.