



# **Culture in Design of Coding Toolkits for Young Learners in Developing Economies in Africa: A Review**

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## **Authors' contributions**

*This work was carried out in collaboration between both authors. Author KCC prepared the first draft of the manuscript. Author KJC reviewed the manuscript. Both authors read and approved the final manuscript.*

## **Article Information**

DOI: 10.9734/CJAST/2023/v42i244177

## **Open Peer Review History:**

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/101230>

**Review Article**

**Received: 12/04/2023**

**Accepted: 18/06/2023**

**Published: 14/08/2023**

## **ABSTRACT**

With the increasing importance and demand of coding skills in today's digital world, developing economies in Africa are putting every effort to include coding education in their educational curriculum. However, the existing coding toolkits for young learners have different cultural orientation making it hard to learn and use thereby making coding education programs and learning outcomes ineffective. The aim of the study was to carry out systematic literature review with particular emphasis on learning environment and pedagogy, use of local language and gender related norms and explored the potential challenges with recommendations in building culturally responsive coding kits. It was found out that the design of culturally responsive coding toolkits has the potential to improve the accessibility, affordability, relevance and effectiveness of coding education for young learners in developing economies in Africa contributing to more effective coding education and therefore helping to bridge the digital divide.

*Keywords: Coding; toolkits; culture; young learners; a cultural divide.*

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*Curr. J. Appl. Sci. Technol., vol. 42, no. 24, pp. 43-50, 2023*

## **1. INTRODUCTION**

Coding skill is becoming important in today's digital world and there is concerted effort from a number of developing economies in Africa to include coding education in the curriculum to cope with increasing demand for coding skills [1, 2]. Introducing coding to learners at an early stage enable them to not only program and actively engage with computers but also teaches them strategies to break down, analyze and solve problems by being logical, critical, analytical, innovative besides fostering teamwork and preparing for future careers in technology [3,4,5]. Introduction of programming skills at an early stage is important in critical thinking, creativity, communication and collaboration (4Cs), which are the most popular skills requirements of the 21<sup>st</sup> century [6].

Culture plays a role in programming by influencing the way learners' approach and understand programming concepts [7]. Cultural differences such as the language used, the types of characters, themes used, and the way information is presented have effect on the design of coding applications and kits, and that the application(s) designed for learners in one culture may not be as effective or appealing to learners in another culture if it does not take into account their cultural background and preferences [7,8]. Cultural considerations in design of coding toolkits increases engagement, motivation, fostering creativity and innovation among young learners thereby improving learning outcomes [6].

According to [9], learners can develop new ways of expressing themselves as they interact with coding toolkits and technologies in addition to developing perspectives about themselves and the digital world. The way coding toolkits are designed determines their interaction with young learners. The work by [10] considered the importance of culture in Human-Centered Computing (HCC) and found out that culture is a key factor that influences one's behavior, expectations, values, perceptions and cognitive reasoning. Therefore, design of culturally responsive coding toolkits positions young learners as creators who can leverage technology to learn about computing [6].

### **1.1 Coding Education in Africa**

Coding education in Africa is still in its early stages with some countries already introducing in

their education curriculum. Most countries in sub-Saharan Africa have policy addressing ICT in education and includes: Angola, Botswana, Côte d'Ivoire, Kenya, Eritrea, Gambia, Nigeria, Mauritius, Seychelles, Namibia, Rwanda, Ghana, Sao Tome and Principe, South Africa, Uganda, and Zambia [2, 11]. However, a few have introduced compulsory coding education in their education curriculum from primary school and includes South Africa and Kenya. According to [1], South Africa was the first African country to implement coding for children in school curriculum in 2020. It started by first training teachers on how to code and teach coding and piloted with 1,000 schools. The South African Government further engaged institutions such as Code College, CodeX, and CodeSpace among others to offer coding and programming courses [1]. In 2022, Kenya launched the syllabus for inclusion of coding as a subject in her new education curriculum in primary and secondary levels [12]. The syllabus which was developed by Kenya Institute of Curriculum Development in partnership with Kodris Africa would offer children an opportunity to learn computer programming.

### **1.2 Problem Statement**

Despite the growing interest in coding and the usefulness of coding toolkits, the existing coding toolkits for young learners are designed by and for developed economies and thus based on Western culture making it difficult for young learners in developing economies, with different cultural orientation, to learn and use them creating a cultural disconnect resulting to ineffective coding education programs and learning outcomes. Developing economies have rich different cultures and the design of coding toolkits should be considered so that they can culturally resonate with young learners thus making the understanding and application of coding easy. In absence of culturally connected coding toolkits for young learners, it would result to missed global job opportunities, widening of the digital divide and limited innovations to develop digital solutions to address local challenges contributing to the development of the community and country.

### **1.3 Significance of the Paper**

Through consideration of coding kits that overcome cultural barriers in developing economies, designers of coding toolkits can create kits that are more affordable, accessible,

engaging and relevant to the learners' experiences. This will improve creativity and innovation among young learners, the effectiveness of the coding education programs and the students' learning outcomes.

#### **1.4 Purpose of the Paper**

This paper sought to do a literature review to explore consideration of culture in design of coding toolkits for young learners in developing economies particularly in Africa then explored the potential challenges with recommendations in building culturally responsive coding kits.

### **2. METHODOLOGY**

The authors carried out systematic literature review by searching the referred scientific journals and electronic databases from 2007 to 2023 guided by the title of the study, the problem statement and the purpose of the study. The search terms were 'coding', 'computational thinking', 'computational kits or toys', 'culture in coding education', 'coding education curriculum or pedagogy', 'coding education and gender related norms', 'coding applications for young learners', 'coding toolkits design', 'early childhood programming' and 'culturally responsive coding'. Articles with emphasis on coding education in Africa or developing economies were given priority. Articles/Journals were rejected if it was found out from the title and the abstract that the study failed to meet the search terms inclusion criteria. Articles or journals with 'culture' but with no 'computational or programming or coding' backing or without reference to children or young learners were excluded. Any ambiguities regarding the application of the selection criteria were resolved through cross referencing. The relevant information from the reviewed articles were then extracted, critically appraised by assessing the quality and finally synthesizing the findings from the studies.

### **3. LITERATURE REVIEW**

#### **3.1 Culture and Context of Coding for Learners**

Various studies have recognized that learners' diverse cultural background can influence their learning experiences [8, 12, 13, 14, 15]. Cultural responsiveness entails being sensitive to the learners' cultural practices, values, beliefs and adapting teaching methods, materials/equipment

and environments to accommodate learners from different cultures [14]. According to [6, 15], cultural responsiveness also informs the design of various technologies such as coding toolkits.

In order to create efficient, affordable, accessible coding toolkits and to improve efficacy of coding education programs and the students' learning outcomes, it is very important to understand culture and background of the learners. By understanding cultural contexts of the learners, it helps designers of coding toolkits besides teachers who can design coding tasks that are more relevant and captivating to experiences of learners [6]. In the study by [10] noted that Human-Centered Computing (HCC) designers need to be aware of cultural differences and to incorporate cultural considerations into any design process, such as that of coding toolkits, so that they are effective and usable for all users.

In a review of 21 published papers by [4], the author examined four different apps or kits popularly used. In the findings, sixteen studies mentioned ScratchJr, and one study the Kodable toolkit. Four papers described studies that combined two kits (Lightbot-ScratchJr, Lightbot-Kodable, Daisy the Dinosaur-ScratchJr, Daisy the Dinosaur-Kodable). Further, [16] and in the analysis of over 30 articles by [17] categorized the coding toolkits for children into tangible or physical, virtual and hybrid with an addition of unplugged kits by [19,20]. Physical kits include components that are tangible [16], Virtual kits are computer-based applications without tangible parts, such as web-based coding games and mobile apps [8] while hybrid toolkits consist of both digital and physical components, e.g., a physical robot and a mobile app to program the robot [17]. Unplugged kits do not involve using a computer and can be done using activities such as paper-based puzzles, games, through physical activities like role-playing or storytelling [20]. From these studies, all the existing coding toolkits mentioned and reviewed were developed by Western economies and culturally challenging to use effectively in developing economies especially in Africa.

A research was carried out by [18] on the development and delivery of an online smartphone-based coding course called SuaCode (built using a Java-based programming language) to teach programming fundamentals to Ghanaian students. The researchers designed the course to be visual, interactive, and fun. Although the findings reported that the SuaCode

online smartphone-based coding course was effective in teaching programming fundamentals, there were possibilities of cultural factors, occasioned by Java-based programming language, such as language barriers, socio-economic status and gender impeding the accessibility and effectiveness of programming course delivery to a number of students considering that only 7 of the 30 students (23.3%) completed the first part of the course.

In the analysis of Kenya's launched coding education curriculum for primary and secondary schools by [12] noted that it was at risk of not being successfully implemented due to cultural factors such as socio economic and gender inequalities. In their paper by [6] found out, amongst others, that socioeconomic factors and availability of relevant materials were necessary for successful implementation of computer science education in primary schools. Although the study was based on Austria using programmable robots, the two mentioned factors are related to cultural practices. In other words, [6] appreciated the role of culture in fostering the success of coding education.

The coding inclinations and the projects thereof that children develop are shaped by cultural elements, such as language, education curricula, pedagogy, gender and social norms and accessibility to infrastructure and thus factors to consider when designing coding toolkits for young learners with cultural orientations.

### **3.1.1 Incorporation of local languages**

Most developing economies have indigenous and official languages for example Swahili in most East African and Central Africa Countries besides English or other language of colonial era. Any language barrier with coding toolkits will make it more difficult for young learners to understand coding concepts. The availability and mode of communication of relevant materials including training materials, documentation and algorithms is crucial [21] and thus the design of coding toolkits should consider regional common dialects and languages understood by learners. The popular ScratchJr coding toolkit is available in eighteen languages [3,22] and surprisingly Swahili is not part of the languages. In the analysis of geographical areas with the most ScratchJr usage, [3] found out that 43% of the usage was "Americas" (consisting of North America, South America, Central America, and

the Caribbean), Europe continent with 34%, Asia (12%), Oceania (Australia, New Zealand, and Polynesia) (9%), and Africa (1%). From the results, there is a relationship between translated language and ScratchJr usage and the low usage in Africa could possibly be attributed to the design language of ScratchJr.

### **3.1.2 Learning environment and pedagogy**

According to [7], cultural context in which a student is learning to code can have an impact on the effectiveness of the teaching and thus an important factor to consider when designing coding kits, curricula and teaching resources. It was further asserted by [7] that different cultures may have different attitudes towards coding and technology, which can affect how students engage with the coding kits and material. For example, some educational cultures may emphasize repetitive learning, memorization, creativity, or collaboration, which may be emphasized in programming classes and influence the design of coding toolkits. Learners from cultures with a strong emphasis on rote learning and memorization may struggle with programming concepts that require more abstract thinking and problem-solving skills [21].

Empirical investigation of cultural considerations on the development of technological intersubjectivity in a computer supported collaborative learning environment with three independent pairs from different or similar cultures (Americans and Chinese) was carried out by [23]. It was found out that members of different cultures used the technology differently in their interaction and formed differential relations with and impressions of each other. The cultural differences empirically demonstrated in this experimental study influence the design, development, and evaluation of technology for learning environments example of coding toolkits.

In order to improve abstract thinking and problem-solving skills among learners in Kenya, the government introduced new education system and curriculum, Competency Based Curriculum (CBC), which aims to promote hands-on training, innovativeness and acquisition of new knowledge through observation, experiential learning and practical experimenting and changes the cramming narrative prevalent with 8-4-4 system [24] and thus paved way for introduction of coding education.

Given that the learning for developing economies is traditionally collaborative, the design of coding toolkits should further consider parents' concerns which include limited programming knowledge to provide help and lack of experience to scaffold especially when their children encounter bugs in the code or the code is not working in desired ways [5].

In their study by [2] highlighted factors affecting the implementation of coding education in Africa and included: exclusion of programming in the curriculum, teacher professional development, ICT infrastructure (computers, hardware, internet, software, etc.), funding and weak policies. The study by [2] further noted that teaching methods and curricula for coding education should be culturally responsive to give the students a positive experience and to ensure that all students have similar learning outcomes.

### **3.1.3 Gender-related customs**

In the study by [8], they sampled 110 coding kits used by young children aged seven and below and examined their design features from a gender perspective using a framework of gender-related design features in toys through the dimensions of colors, physical forms, and activity types. The findings revealed an unbalanced gender representation in coding kit designs regarding colors, physical forms, and activity types in which the application of boy-oriented design elements outweighs girl-oriented design features. This study resonates with the cultural consideration when designing coding toolkits since the study by [8] recommended designing of coding kits that are more gender inclusive for young children, especially young girls whose preferred gender-oriented features are particularly underrepresented in most current designs.

In the study by [26] found out that programming concepts (such as event handling, looping, variables declaration, operators, conditional statement, etc.) were used by students when they were developing a game project using ScratchJr toolkit and that there was strong interrelation among these concepts. The authors further found out that majority of the girl's participants in a coding class had no prior knowledge of what coding is and how-to code with ScratchJr, a block-based programming environment for children. Girls lack of or limited computing related literacy, experiences, and interests may further lead to lack of confidence in

studying, practicing, and learning programming activities [26]. However, the authors did not consider cultural factors such as educational background, socio norms, language, and access to technology which may influence how children approach coding and the types of projects they create.

In the evaluation of the computational thinking concepts supported in Kodable, Lightbot, Daisy the Dinosaur, and the ScratchJr, [4] found out that none of the apps evaluated in the study supported variables and noted that *"It should not be considered a problem as researchers claim that young children have problems understanding abstract representations such as variables"*. To demystify this abstraction, the coding kits should have capabilities of capturing variables using cultural gender such-like roles for example cooking of food in girls, athletics or taking care of animals amongst boys in some communities. According to [27], developmental considerations such as variables must be included when designing educational curriculum for young children which can include cultural illustrations. On their study on Implementation of Computer Science Education in South Africa by [1], they found out that traditional gender roles in South Africa discourage girls from developing an interest in coding technology and a number of interventions had been made including formation of coding clubs for girls to help develop strong foundation of programming skills. Gender stereotypes play a negative role in creating the current gender imbalance in computing related design and usage [25,30]. In coding projects, girls typically program stereotypical scenes or artifacts aimed at girls, such as houses, flowers, rainbows, unicorns, and Barbie dolls, and are less interested in computer projects that contain features aimed at boys [25, 26].

## **4. SUMMARY OF THE FINDINGS**

The design of culturally responsive coding toolkits has the potential to improve the accessibility and effectiveness of coding education for young learners in developing economies in Africa. Additionally, culturally responsive coding toolkits helps to promote inclusivity by recognizing and valuing the diversity of learners from different cultural backgrounds. From the aforementioned studies, the designers should consider local and official languages for developing economies in order to improve accessibility, learnability and usage of coding toolkits. Furthermore, the culture of

learning environment and pedagogy of a particular country have a great bearing on the design of coding toolkits and thus designers should consider incorporating traditional teaching methods such as storytelling and group works when coming up with the kits. Lastly, it is very important to design coding kits that are more gender inclusive and accommodates cultural gender norms for young children which will result to enhanced understanding of coding concepts and thus better coding learning outcomes. By considering cultural factors such as local language, pedagogy, and gender norms, designers can create tools that are more engaging and relevant to the learners' experiences

## **5. POTENTIAL CHALLENGES AND RECOMMENDATIONS**

The design of coding toolkits for young learners that are culturally responsive is in the right direction. However, there are potential challenges that designers need to consider. The first possible challenge is how to ensure the coding toolkits are culturally sensitive and appropriate for all young learners, irrespective of their cultural context. According to [28], system features appropriated for one culture may not be suitable for everyone though within the same cultural set up; as well as system's design that needs to be adapted for different cultures posing a challenge of inclusivity for all cultural needs. The quality of user experience and interactions is intricately related to the users' cultural characteristics [28]. To create culturally sensitive kits, one need to understand different cultural perspectives holistically with the user/human-centered design approach, and to avoid stereotyping cultures or making implicit assumptions in the design of the coding toolkits [25,26,29]. To accommodate cultural differences such as the types of characters, themes and the presentation of information, then the design of coding kits should consider provision of options for personalization or customization to suit cultural background and preferences [8].

Another potential challenge to deal with is having coding toolkits designers and developers to learn about different cultures or ethnic groups with the purpose of alignment of the kits' design. In the studies by [31,32] recommended some ways of learning new cultures which can be adopted in the design of coding kits. In this scenario, working with designers from diverse cultural

backgrounds with a view to understanding cultural preferences and practices, incorporating feedback from kits' users [5] with diverse cultural backgrounds into the coding toolkits design process, carrying out research on diverse cultural customs in addition to engaging in cross-cultural training or workshops to have better understanding of various cultures. The kits can also embed simple algorithms or pseudocode to help educators, parents/guardians and learners to navigate any coding challenge.

According to [21], they noted the language barriers due to different communication styles as another potential challenge. To supplement language-based instructions, designers can incorporate multimedia resources or visuals aids in the kits [16]. Furthermore, the composition of team members with diverse language and backgrounds should be considered in the coding toolkits design process. Additionally, in order to improve design features and activity strategies of coding kits that can engage young learners in meaningful ways even without the presence of professional educators or parents to scaffold the learning experience, the animation technology can be incorporated.

## **6. LIMITATIONS**

This paper has been limited by inexistence of empirical studies that have specifically focused on the design of coding toolkits for young learners in developing economies in Africa. The paper further limited the review to learning environment and pedagogy, use of local language in the kits and consideration of gender related norms.

## **7. CONCLUSION**

This paper has highlighted critical considerations when designing culturally responsive coding toolkits for young learners in developing economies in Africa. It was found out that coding toolkits that are designed and developed without taking into account the cultural context of the young learners may fail to provide meaningful learning experience and outcome. Additionally, this paper has discussed key considerations when designing culturally appropriate coding toolkits which included the learning environment and pedagogy, use of local language in the kits and gender related norms. By designing coding toolkits that overcome cultural barriers in developing economies in Africa, coding

education would become more affordable, accessible, engaging, relevant and effective to the learners' experiences which contributes to more effective coding education and therefore helping to bridge the digital divide. The authors recommended that future works could carry out empirical studies with incorporation of pedagogical theories, models and frameworks relating to coding and expansion of cultural factors to include religious beliefs and cultural values amongst others.

### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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*The peer review history for this paper can be accessed here:*  
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