Culture in Design of Coding Toolkits for Young Learners in Developing Countries in Africa: A review

Abstract

With the increasing importance of coding skills in today's digital world, developing countries in Africa are putting every effort to include coding education in their educational curriculum to match the increasing demand for coding skills. Even though there is increasing interest in coding, present coding toolkits for young learners are designed for developed nations and based on Western culture, making it hard for young people in developing nations with different cultural orientations to learn, causing cultural divides thereby making coding education programs and learning outcomes ineffective. This paper carried out a literature review on cultural considerations particularly learning environment and pedagogy, use of local language, and consideration of gender-related norms in the design of coding toolkits for young learners in developing economies, and explored the potential challenges with the recommendations. It is hoped that this paper lays a foundation for critical considerations when designing culturally responsive coding toolkits for young learners in developing economies in Africa.

Keywords: coding, toolkits, culture, young learners, a cultural divide

1.1 Introduction

Coding skill is becoming important in today's digital world and there is a concerted effort from several developing countries in Africa to include coding education in the curriculum to cope with the increasing demand for coding skills (Fares et al., 2021; Tshukudu et al., 2023). Introducing coding to learners at an early stage enables 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, and innovative besides fostering teamwork and preparing for future careers in technology (Papadakis, 2021; Yu et al., 2020; Bers, 2018). 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 21st century (Tengler et al., 2020).

Culture plays a role in programming by influencing the way learners' approach and understand programming concepts (Duncan et al., 2014). Cultural differences such as the language used, the types of characters, themes used, and the way information is presented affects the design of coding applications and kits, and 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 (Cen et. al, 2023; Duncan et al., 2014). Cultural considerations in the design of coding toolkits increase engagement, and motivation, fostering creativity and innovation among young learners thereby improving learning outcomes (Tengler et al., 2020).

According to Mia and Yaswin (2020), 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. Salgado et al. (2015) considered the importance of culture in Human-Centered Computing (HCC) and found that culture is a key factor that influences one's behavior, expectations, values, perceptions, and cognitive reasoning. Therefore, the design of culturally responsive coding toolkits positions young learners as creators who can leverage technology to learn about computing (Tengler et al., 2020).

1.2 Coding Education in Africa

Coding education in Africa is still in its early stages with some countries already introducing it in their education curriculum. Most countries in sub-Saharan Africa have policies addressing ICT in education and including Angola, Botswana, Côte d'Ivoire, Kenya, Eritrea, Gambia, Nigeria, Mauritius, Seychelles, Namibia, Rwanda, Ghana, Sao Tome and Principe, South Africa, Uganda, and Zambia (Tshukudu et al., 2023; UNESCO, 2019). However, a few have introduced compulsory coding education in their education curriculum from primary school and including South Africa and Kenya. According to Fares et al. (2021), South Africa was the first African country to implement coding for children in school curricula 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 (Fares et al., 2021). In 2022, Kenya launched the syllabus for the inclusion of coding as a subject in her new education curriculum at the primary and secondary levels (Luvanda, 2022). 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.

1.3 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 countries and thus based on Western culture making it difficult for young learners in developing countries, with different cultural orientations, to learn and use them creating a cultural disconnect resulting to ineffective coding education programs and learning outcomes. Developing countries 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 will result in missed global job opportunities, widening of the digital divide, limited innovations to develop digital solutions to address local challenges and contribution to the development of the community and country, dependence on foreign expertise for digital solutions and perpetuation of existing inequalities in access to coding education and opportunities, particularly for those from marginalized communities but with rich cultures.

1.4 Significance of the Paper

Through consideration of coding kits that overcome cultural barriers in developing countries, 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 student's learning outcomes.

1.5 Purpose of the Paper

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

2. Literature Review

2.1 Culture and Context of Coding for Learners

Various studies have recognized that learners' diverse cultural background can influence their learning experiences (Cen et al., 2023; Luvanda, 2022; Gay, 2018; Scott et al., 2015; Eglash et al., 2013). Cultural responsiveness entails being sensitive to the learners' cultural practices, values, and beliefs and adapting teaching methods, materials/equipment, and environments to accommodate learners from different cultures (Gay, 2018). Cultural responsiveness also informs the design of various technologies (Tengler et al., 2020; Scott et al., 2015) such as coding toolkits.

To create efficient, affordable, accessible coding toolkits and to improve the efficacy of coding education programs and the students' learning outcomes, it is very important to understand the culture and background of the learners. Understanding the cultural contexts of the learners helps designers of coding toolkits besides teachers who can design coding tasks that are more relevant and captivating to the experiences of learners (Tengler et al., 2020). Salgado et al. (2015) noted that HCC designers need to be aware of cultural differences and incorporate cultural considerations into any design process, such as that of coding toolkits so that they are effective and usable for all users.

Papadakis (2021) in a review of 21 published papers 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, Yu and Roque (2019) and in the analysis of over 30 articles by Elena et al. (2022) categorized the coding toolkits for children into tangible or physical, virtual and hybrid. In addition, Niklas (2021) added unplugged kits. Physical kits include tangible components (Yu & Roque, 2019), Virtual kits are computer-based applications without tangible parts, such as web-based coding games and mobile apps (Cen et al., 2023) while hybrid toolkits consist of both digital and physical components, e.g., a physical robot and a mobile app to program the robot (Elena et al., 2022). Unplugged kits do not involve using a computer and can be done using activities such as paper-based puzzles, and games, through physical activities like role-playing or storytelling (Niklas, 2021). From these studies, all the existing coding toolkits mentioned and reviewed were

developed by Western countries and are culturally challenging to use effectively in developing countries, especially in Africa.

Boateng et al. (2021) researched 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 several students considering that only 7 of the 30 students (23.3%) completed the first part of the course.

Luvanda (2022) in the analysis of Kenya's launched coding education curriculum for primary and secondary schools noted that it was at risk of not being successfully implemented due to cultural factors such as socio-economic and gender inequalities. Tengler et al. (2020) in their paper found out, amongst others, that socioeconomic factors and the availability of relevant materials were necessary for the 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, Tengler et al. (2020) 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.

2.1.1 Incorporation of Local Languages

Most developing countries have indigenous and official languages for example Swahili in most East African and Central Africa Countries besides English or other language of the 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 are crucial (Resnick & Rusk, 2020) 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 (Bers, 2018; Strawhacker et al., 2018) and surprisingly Swahili is not part of the languages. In the analysis of geographical areas with the most ScratchJr usage, Bers (2018) found 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 be attributed to the design language of ScratchJr.

2.1.2 Learning Environment and Pedagogy

According to Duncan et al (2014), the 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. Duncan et al (2014), further asserted that different cultures may have different attitudes toward 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. Resnick & Rusk (2020) found out that 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.

Vatrapu (2008) carried out an 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). It was found 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 coding toolkits.

To improve abstract thinking and problem-solving skills among learners in Kenya, the government introduced a new education system and curriculum, the 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 (Amutabi, 2019) and thus paved way for the introduction of coding education.

Given that learning in developing countries 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 (Yu et al., 2020)

Tshukudu et al. (2023) in their studies highlighted factors affecting the implementation of coding education in Africa and included: the exclusion of programming in the curriculum, teacher professional development, ICT infrastructure (computers, hardware, internet, software, etc.), funding, and weak policies. Tshukudu et al. (2023) 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.

2.1.3 Gender-Related Customs

In the study by Cen et. al (2023), 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 Cen et. al (2023) recommended designing 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.

Papavlasopoulou et al. (2018) in their study 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 the ScratchJr toolkit and that there was strong interrelation among these concepts. The authors further found out that the 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 a lack of confidence in studying, practicing, and learning programming activities (Papavlasopoulou et al., 2018). 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.

Papadakis (2021) in the evaluation of the computational thinking concepts supported in Kodable, Lightbot, Daisy the Dinosaur, and the ScratchJr 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, and athletics or taking care of animals amongst boys in some communities. According to Relkin et al. (2021), developmental considerations such as variables must be included when designing educational curricula for young children which can include cultural illustrations. Fares et al. (2021) in their study on the Implementation of Computer Science Education in South Africa found that traditional gender roles in South Africa discourage girls from developing an interest in coding technology and several interventions had been made including the formation of coding clubs for girls to help develop a strong foundation of programming skills. Gender stereotypes play a negative role in creating the current gender imbalance in computing-related design and usage (Sullivan & Bers, 2013; Graßl et al., 2021). 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 (Papavlasopoulou et al. 2018; Graßl et al., 2021).

From the aforementioned studies, the designers should consider local and official languages for developing countries to improve accessibility, learnability, and usage of coding toolkits. Furthermore, the culture of the learning environment and pedagogy of a particular country has a great bearing on the design of coding toolkits and thus designers should consider incorporating traditional teaching methods such as storytelling and group work 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 in an enhanced understanding of coding concepts and thus better coding learning outcomes.

3. 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 Lee et al. (2018), system features appropriated for one culture may not be suitable for everyone though within the same cultural set up; as well as system 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 (Lee et al., 2008). To create culturally sensitive kits, one needs to understand different cultural perspectives holistically with the user/human-centered design approach, and avoid stereotyping cultures or making implicit assumptions in the design of the coding toolkits (Shah, 2013; Papavlasopoulou et al. 2018; Graßl et al., 2021). To accommodate cultural differences such as the types of characters, themes, and the presentation of information, then the design of coding kits should consider the provision of options for personalization or customization to suit cultural backgrounds and preferences (Cen et. al, 2023).

Another potential challenge to deal with is having coding toolkit designers and developers learn about different cultures or ethnic groups with the purpose of alignment of the kits' design. Tomasello (2016) and Hodkinson et al. (2007) in their studies 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 to understand cultural preferences and practices, incorporate feedback from kits' users (Yu et al., 2020) 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 a 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.

Resnick & Rusk (2020) further noted that language barriers due to different communication styles could be another potential challenge. To supplement language-based instructions, designers can incorporate multimedia resources or visual aids in the kits (Yu & Roque, 2019). Furthermore, the composition of team members with diverse languages and backgrounds should be considered in the coding toolkit design process. Additionally, 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, animation technology can be incorporated.

4. Limitations and Future Research

This paper has been limited by the inexistence of empirical studies that have specifically focused on the design of coding toolkits for young learners in developing countries. The paper further limited the review to the learning environment and pedagogy, the use of local language in the kits, and the consideration of gender-related norms. Thus, future studies to consider empirical studies with the incorporation of pedagogical theories, models, and frameworks relating to coding and expansion of cultural factors to include religious beliefs amongst others.

5. Conclusion

This paper has laid a foundation for critical considerations when designing culturally responsive coding toolkits for young learners in developing economies. In particular, the paper has reviewed and discussed culture and the context of coding, learning environment, and pedagogy, the use of local language in the kits, and consideration of gender-related norms. The paper further explored the potential challenges with recommendations in the cultural consideration in the design of coding toolkits. By designing coding toolkits that overcome cultural barriers in developing countries, coding education will become more affordable, accessible, engaging, relevant, and effective to the learners' experiences.

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