Robotics Across the Zimbabwean Curriculum: an evaluability assessment of the RACR framework

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Abstract- One of the most emerging technologies and demanding fields in contemporary engineering education nowadays is robotics. Zimbabwean Elearning Institute (ELI) has taken a bold step in developing and implementing a new robotics educational program that might be applied across Zimbabwean educational curriculum. This paper reviewed Zimbabwean robotics education and described the ELearning Institute (ELI)'s current work toward establishing the program. It described the Reading, Animation, Coding, and Robotics (RACR) framework of the ELearning Institute (ELI), and then employed evaluability assessment and explained the steps involved in the application of the framework.

Index Terms- Coding and Robotics, RACR framework, Curriculum, Evaluability assessment, Robotics education

I. INTRODUCTION

Robotisation has proved to be a global technological megatrend (Pantic et al., 2016; Shmatko & Volkova, 2020), which makes robotics to develop rapidly with an increase in demand worldwide. Robotics will assist learners to be globally relevant and employable as coding and robotics are interrelated with Information Communication Technology (ICT) and Engineering. Therefore, there is a need for the African educational system to incorporate robotics in their curriculum (Ahmed & La, 2019). Zimbabwe, as well as South Africa is creating educational system that integrates robotics.

According to Bezuidenhout (2021) educational system needs to strengthen up Science Technology, Engineering and Mathematics (STEM) literacy in the national curriculum for Grade R-9. The technological trend has necessitated the creation of an effective higher education system that meets the increased demand for skilled specialists in the field of robotics engineers (Shmatko & Volkova, 2020). Guo (2017) added that there is a shortage of skills in robotics, and such a lack of coding skills may lead to a severe shortage of ICT skills by 2030. ELearning Institute (ELI) is an educational organization in Zimbabwe that saw these problems and diverse a means of bridging the gaps between the demand and supply of Computer Programming (Coding) skills. ELI developed Afrocentric Content to ensure that African educators and learners bring African content to the digital discourse. ELI aimed at developing an ICT for the Teachers' training program that enabled teachers to teach the digital skills of Reading, Animation, Coding, and Robotics to K12.
The ELearning Institute's strategic response has been to formulate a framework called the Reading, Animation, Coding and Robotics (RACR) Framework. The RACR Framework uses Themba and the Big5 brand. Themba and the Big5 is an African story where Themba, an African boy growing up in Savannah, becomes friends with a young African lion, African leopard, African elephant, African rhino, and African buffalo. The eLearning Institute uses the Themba and the Big5 brand as the source content to spread it across the four pillars of the RACR Framework.

The four pillars of the RACR Framework are:
Pillar 1: Reading-
Pillar 2: Animation
Pillar 3: Coding
Pillar 4: Robotics

The goal of RACR is to teach children coding, robotics and Animation, therefore, before learners get into the digital skills, they must

learn how to read and that's where reading comes into play and hence, the development of the books on Themba and the Big 5. The RACR framework has the potential for expansion through the assimilation of other languages, given that the eLearning Institute will sell the idea outside Zimbabwe. Moreover, indigenous language translations are incorporated in RACR to help the teachers understand the content better. The Framework also focused on teaching students to read through storytelling presented in a familiar language that they know. Kids love animals and storytelling (Thambu, 2017). These children can then see themselves in the language and the environment where they come from.

In order to address the gender gap in tech, RACR program also made provision for the girl child by introducing Girls in Robotics and the STEM related Careers to cater for girls. All these are emerging as standard components for teaching kids coding. Picture story of Themba and the Big 5 is the main source of stories for the kids and is a base for coding. Computer Science (CS) is fast approaching the same prominence as literacy in education (DiSessa, 2018; Williamson, 2017). It was initially preserved for tertiary education but has recently moved to early year's education (Bezuidenhout, 2021). The Ministry of Primary and Secondary Education responded positively to meet international standard by introducing the ICT curriculum that will run from 2015 to 2022.

The purpose and value of evaluability assessment for the RACR framework

Evaluability Assessment is a pre-evaluation activity which, in addition to increasing the usefulness and relevance of outcome evaluations can identify activities unlikely to lead to program outcomes, build evaluation capacity, and assist in developing or improving a program (Trevisan & Walser, 2014). Evaluability Assessments help to determine whether it is possible to evaluate this program, if the program is properly designed and operating according to design, and what steps can be taken to implement the program (Gilchrist, 2014). It serves to sharpen the focus of the RACR intervention as it establishes the measurability and impact (Craig & Campbell, 2015). The above detailed functionality of the RACR framework made evaluability to strengthen or improve the program before the next level of evaluation can begin (Gilchrist, 2014). RACR framework evaluability assessment can help build consensus on program outcomes among program implementers, program staff, decision makers within the organization, partners, and funders. Policymakers and practitioners are involved from the beginning of the development and evaluation of RACR framework. Craig & Campbell (2015) forestall commitments to evaluate evaluability assessments where further development is required, or little realistic expectation of benefit is needed, and then make the evaluations that are undertaken more useful. The scope of an evaluation is influenced by resources available. Resources may include time, money, equipment and skills, examples of the program resources are Financial Support, Guides, translators, Human resources. The eLearning Institute (ELI) teaches, Art Material, clay modelling; Human and financial resources, Software for programming language, Coders, Teacher peer trainers, and Partners and evaluability assessment would prevent expending these resources prematurely or inappropriately. The evaluability assessment for the RACR programme in Bulawayo focuses on teaching kids about STEM based careers in order to address core skills identified in the Zimbabwe Ministry of Primary and Secondary Education curricula (Source: http://www.computerweekly.com/news).

This study reviews the Zimbabwean academic curriculum and describes the RACR Framework as a strategic product roadmap for developing educational content under the four pillars of Reading, Animation, Coding, and Robotics.

II. METHODOLOGY

Evaluability assessment of the RACR framework follows the sequential steps as specified in Public Health Ontario (2018). The amount of time and effort devoted to each activity varies from one evaluability assessment to the next, depending on the strength of the existing evidence base, and that the complexity or degree of development of the intervention, the number of key stakeholders and so on. Trevisan and Walser (2014) agreed with this view and added that any useful evaluability assessments should be completed as quickly as possible, that is, within three months of inception so that the process does not delay decisions about the implementation. They proposed a timetable in agreement with the stakeholders at the outset, with built-in-time for clearing the final report.

The evaluability assessment followed these steps

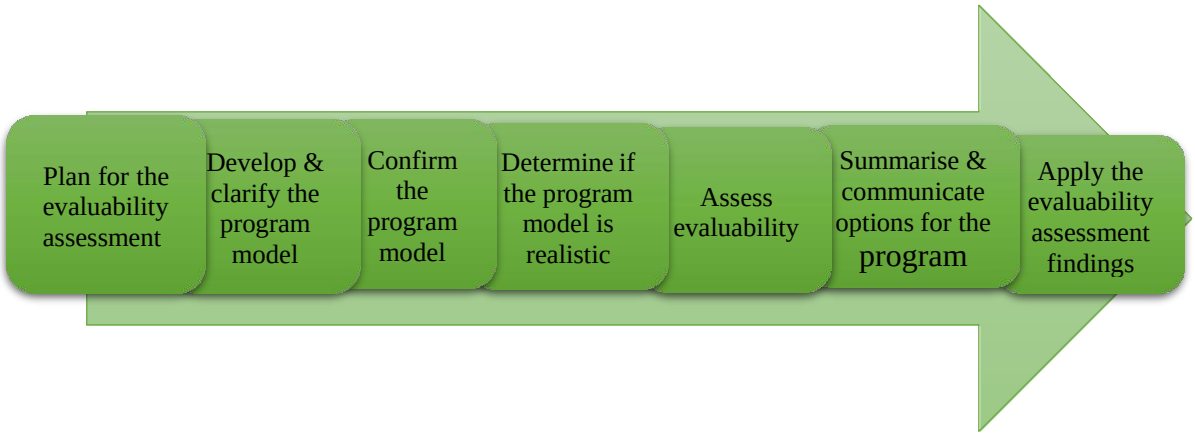

Fig 1: Steps to conduct an evaluability assessment

1) Planning for evaluability assessment

Planning for the RACR program would also include generating terms of reference (TOR) which includes how decisions regarding the Evaluability assessment will be made, creating work plans and developing a budget (Public Health Ontario, 2018).

2) Develop and clarify the program model

Several methods can be used here: for example: document review, interviews, feedback from the stakeholders, observation and other data collection methods like small group discussions in the form of focus group for the stakeholders.

3) Confirm the program model

As the program model is organised and presented in a simplified manner, the information and data from the model would need to be confirmed. Site visits or observations, meetings and interviews on the evaluability assessment team would confirm the program model that would have been created in the first step.

4) Determine if the program model is realistic

In this step, the evaluators assessed the likelihood that program activities and available resources led to the program's intended goals and objectives (Public Health Ontario, 2018). Data collection methods used are site visits, observations, a review of the literature, and interviews with the experts.

5) Assess evaluability

Through use of indicators or checklists, discussions with the intended users and program managers, the evaluability assessment workgroup determined if the program meets the conditions necessary to design an outcome evaluation (Zandniapour, 2014).

6) Summarise and communicate options for the RACR program

The results of evaluability assessments are summarised, and recommendations developed for the program and its evaluation.

7) Application of evaluability assessment findings

Consensus on the changes to the program was reached with the decision makers after the submission of the evaluability assessment report. Decisions were made on how the program is operated in practice; availability of resources and timelines of outcome evaluation; how to use the evaluation results and whether to proceed with the evaluation.

III. EVALUABILITY ASSESSMENT

Now it is the time to articulate the research work with ideas gathered in above steps by adopting any of below suitable approaches:

A. Document Analysis

The researcher reviewed the documents of framework and found that, whilst the Reading Theme of RACR is easy to link to education, the other themes have to be justified by identifying where in the curriculum they link. The following section identifies where Animation, Coding and Robotics link into the curriculum of the Zimbabwean Ministry of Primary and Secondary Education curriculum.

Animation is one of the technologies that the Zimbabwe ICT curriculum mandates young learners to be taught starting at Early Childhood Development (ECD). The software tool specified to teach Animation is MonkeyJam (Čunko & Nox, 2021; Lawson, et al, 2018). Therefore, it is important that teachers and leaners know how to operate MonkeyJam so as to use it to create animated eLearning learning aids, to create animated educational and entertainment cartoons as specified in the curriculum. Once teachers and young leaners know how to animate, they are recommended to apply ICT in Visual, and Performing Arts as specified in the syllabus as shown in Figure 2.

Theatre • The role of theatre, film and animation and puppetry in my home and my culture • Characterisation: Different family members and their roles • Family stories	• respond to a variety of theatre and animation performances from past and present cultures • respond to film from past and present cultures • name family members and their roles • mimic family members depicting their roles • listen to family's stories	• Children's theatre performances • Family characters • Fairytales and folktales • Family stories

Fig 2: Cross curricula application of ICT in Visual and Performing Arts (ECD A)

B. Exploring Robotics in the Zimbabwean Curriculum

The continuous gap between the demand and supply of coders, also known as software engineers, or computer programmers in industry, has led to innovations in answering this challenge. One of the innovations which is becoming a global trend is the introduction of coding as subject beginning in Early Childhood Development (ECD) (Bers, 2019). The Zimbabwean Ministry of Primary and Secondary education adopted this trend and introduces coding and robotics in the National curriculum at early childhood development. The eLearning Institute (ELI) customises their coding curriculum to meet the new syllabus. Figure 3 and figure 4 shows the national curriculum specification for programming at Grade 1 and Grade 3.

Grade 1

TOPIC	OBJECTIVES • Learners should be able to:	• CONTENT/ COMPETENCIES
7.15 PROGRAMMING	• move screen objects using a set of instructions • ordering a sequence of commands into a programmable robot or toy • demonstrate how computer processes instructions and commands (computational thinking)	• Devices and commands - Program Algorithms - Turtle and electronic toys

Fig 3: Grade 1 National Curriculum Specification

Grade 3

TOPIC	LEARNING OBJECTIVES Learners should be able to:	CONTENT/ COMPETENCIES
7.7 PROGRAMMING	• outline how a computer processes instructions and commands • demonstrate that devices are controlled by a sequence of instructions or actions • create sequence of instructions for a variety of programmable devices • edit a sequence of instructions for a variety of programmable devices	• Sequence of Instructions - Programming

Fig 4: Grade 3 National Curriculum Specification

The Ministry of Primary and Secondary Education (Zimbabwe) seems to be aware of the impending change in the job market and has introduced robotics to young learners starting in Early Childhood Development as seen in their ECD A and ECD B curricular as shown in figure 5 and figure 6 respectively.

ECDA

Topic	Objectives Learner should be able to:	Competencies
7.5 PROGRAMMING	• identify different electronic toys • guide a floor robot	• Control • Robotics

Fig 5: ICT curriculum specifying expected competences at ECD A

ECDB

Topic	Objectives Learners should be able to:	Competencies
7.10 PROGRAMMING	• guide a floor robot in relation to other objects on a floor map • identify the different tasks that the robots can do	• Control -Robotics

Fig 6: ICT curriculum specifying expected competences at ECD B

Moreover, figure 7 is an extract from the ICT for Teachers (ICTfT) Robotics Guide guiding teachers how to use Robo-Shumba to implement lessons that will teach young learners robot behaviours as specified in the curriculum.

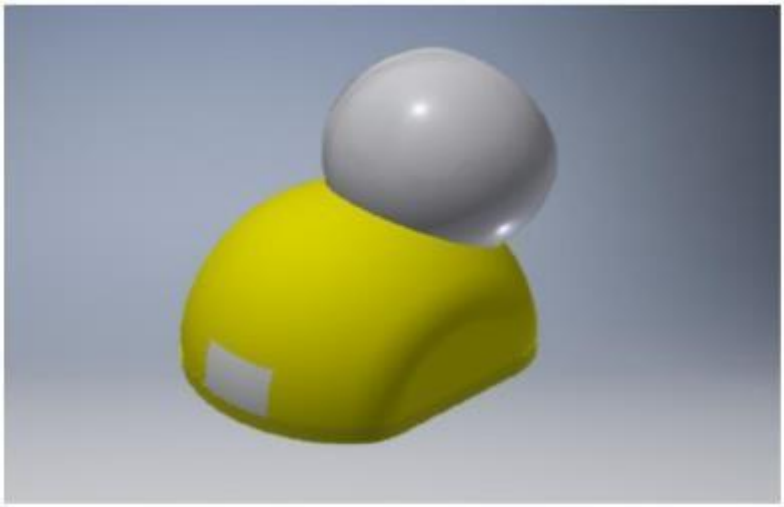

Fig 7: Robo5 ICT for Teachers (ICTfT) Robotics.

C. RACR Response to the Zimbabwean Curriculum

The curriculum specifies the use of Scratch as the block and Logo as the text languages to be used by learners. The ELearning Institute (ELI) provides ICT for Teachers (ICTfT) Guides for Scratch and another one for Logo. Additionally, The Institute has developed Scratch Programming Guide to show teachers how to teach programming in Scratch as specified by the ICT curriculum. See Scratch Teachers

Guide extract in figure 8.

Fig 8: Scratch Teachers Guide

D. RACR Effectiveness

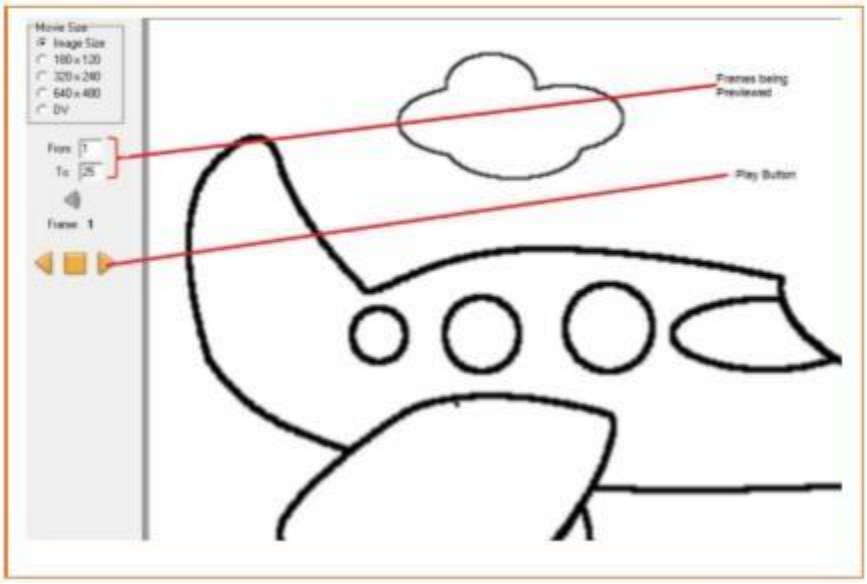

Fig 9: Animation Guide MonkeyJam Teachers Guide

The eLearning Institute prepared the MonkeyJam ICT for Teachers Application Guide as in figure 9 extract. Moreover, Themba and the Big5 is one of the folktales that teachers and learners can tell and retell as specified in the syllabus. The ELearning Institute (ELI) provides the still images from the Themba and the Big5 that teachers and learners can use as input to create animated eLearning aids and other outputs recommended in the curriculum. The animated cartoons can be produced in any of the indigenous languages taught in the school. This achieves the difficulty task of linking the child's culture and context to ICT as specified in the curriculum.

The advantages of linking the child's culture to ICT are multiple and some of them are:

- Young learners grow up knowing that their language, culture and context can develop digital capability.

- Young learners develop ability to contribute Afrocentric digital content thus increasing the availability of Afrocentric content on the web and other digital platforms.
- Children from other cultures are exposed to Afrocentric content and grow up to develop inclusive ICT environment.
- Teachers develop skills of applying ICT in cross culture and cross-curricula applications as specified by the ICT curriculum.
- Learners and teachers develop the basis for developing inclusive ICT.
- Learners and teachers develop a culture of skill of developing ICT solutions that address local needs.

E. ICT for Teachers (ICTfT) learning material

The learning material is available in different local languages such as Shona, Ndebele, Kalanga, Sotho, Setswana, Chivenda and even French. This is accompanied by multiple modes of instruction (face-to-face, online written, simulations, etc) for better understanding of the RACR framework. Besides, the course outline and design are available with clear course objectives; the course structure is also simple to understand with relevant real-life case examples and a summary of frequently asked questions and additional enriching learning material resources for the teachers. Given the above document analysis for animation, coding and robotics, the following paragraphs explores the RACR framework and highlight its relevance to STEM Careers.

F. Exploring RACR Effectiveness

The RACR framework made provision for the teaching of STEM based careers in order to address the core skills identified in the Zimbabwean Ministry of Primary and Secondary Education curricula as follows:

The RACR Framework incorporated aviation as a career and a book on aviation was produced to create awareness of aviation among children. As can also be seen on the pictorial representation in Figure 10, aviation has relevant material on it. Themba and the Big 5 are talking about the aeroplane and they then promise each other that they will visit the airport and learn everything about Robotics. This is STEM related as depicted by the Aviation as a career in figure 10

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Fig 10: Aviation as a career

Moreover, electronics has also been incorporated as a career in the RACR framework. This was done by introducing paper circuits in the form of LED using lemon as power source in figure 11.

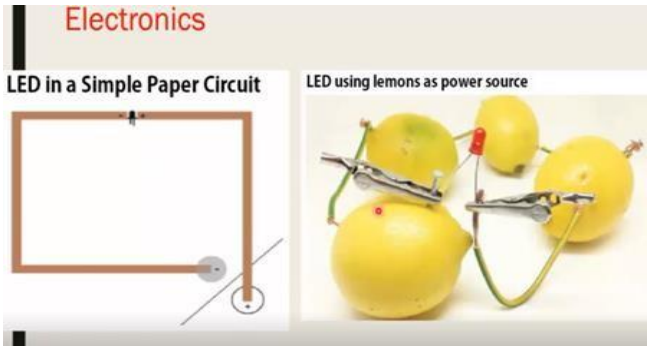

Fig 11: Electronics as a career

In the pictorial diagram above, the children are exposed into electronics by use of paper circuits instead of using high voltage. That is improvising by using what is available in the environment. Paper circuits powers an LED. Children learn new and innovative ways of powering the LED using lemons. In this Career, children go through all the principles of electronics using paper circuits.

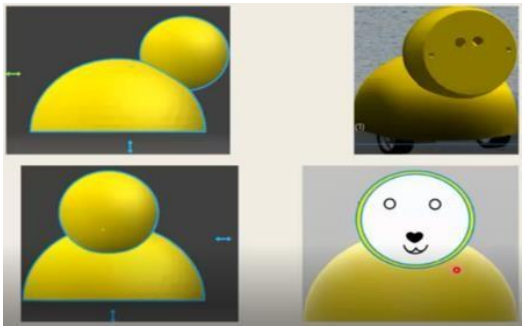

Fig 12: Robo-Shumba

In terms of robotics and coding, the learners were taught using Robo-Shumba as depicted by the picture to do coding (Figure 12 above).

The ELearning Institute (ELI) designed an educational robot (Robo-Shumba) that kids programme using Scratch and move on the floor. All these are emerging as standard components for teaching kids coding. The ELearning Institute (ELI) has also developed an online school where partners can enrol students.

Reading: The Institute designed a six-part picture story eBook series called Themba and the Big5 (ISBN 978-0-7974-8880-9) targeting K12. The picture books series covers reading, arithmetic, science, and tech, social sciences. Themba and the Big5 picture book (Figure 13) has been translated into different languages including French.

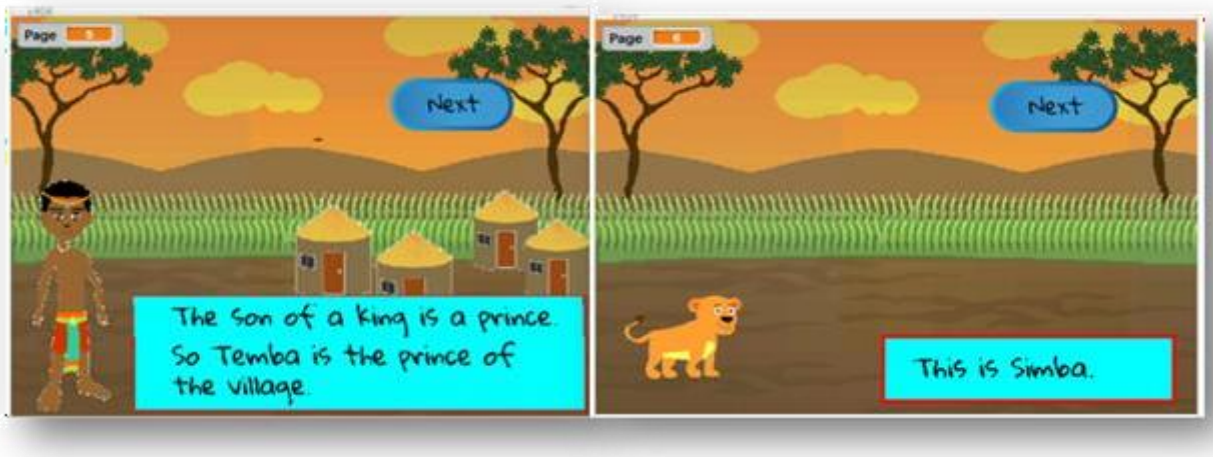

Fig 13: Example of picture story book (electronic and printed)

G. COMPARING ROBOTICS EDUCATION IN OTHER COUNTRIES

Country	Stage	Method	Target Result
Zimbabwe	Early years to K12	Story book, Themba and the BIG5	Reading, coding, robotics and Animation,
Australia	Preparatory years to Final years in High Schools	Building blocks Robotics groups, Holiday programs, and After-School clubs	coding, creative thinking, problem solving, and design
United Kingdom	Age 5 to 14	Strong, stale structures Electrical systems Sketches, Plans & 3D	Critical thinking & Problem Solving

IV. CONCLUSION

Although any program can be evaluated, evaluability assessment can also show whether a program can be meaningfully evaluated and contribute to improved program performance. This particular project has shown that it can be evaluated. The program has also achieved the following: While highlighting the components of the project, it has also assessed the feasibility and appropriateness of the designs for further evaluation. The program has also provided information for the assessor to understand stakeholder awareness and interest in the program. As such procedures for communication have been established further strengthening effective communication, and good interpersonal skills and strategies which facilitates collaboration and teamwork.

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REFERENCES

[1] Ahmed, H., & La, H. M. (2019, March). Education-robotics symbiosis: An evaluation of challenges and proposed recommendations. In *2019 IEEE Integrated STEM Education Conference (ISEC)* (pp. 222-229). IEEE.

[2] Bers, M. U. (2019). Coding as another language: A pedagogical approach for teaching computer science in early childhood. *Journal of Computers in Education*, *6*(4), 499-528.

[3] Bezuidenhout, H. S. (2021). An early grade science, technology, engineering and mathematics dialogue reading programme: The development of a conceptual framework. *South African Journal of Childhood Education*, *11*(1), 1-10.

[4] Brunner, R., Craig, P., & Watson, N. (2019). Evaluability assessment: An application in a complex community improvement setting. *Evaluation*, *25*(3), 349-365.

[5] Chaidi, E., Kefalism C., Papagerasimou, Y., & Drigas, A. (2021) Educational robotics in primary education: A case of Grecce. Research, Society, and Development. *10*(9)

[6] Cooksy, L. J., Gill, P., & Kelly, P. A. (2001). The program logic model as an integrative framework for a multimethod evaluation. *Evaluation and program planning*, *24*(2), 119-128.

[7] Craig, P., & Campbell, M. (2015). Evaluability Assessment: a systematic approach to deciding whether and how to evaluate programmes and policies.

[8] Čunko, A. V., & Nox, A. (2021). Stop-animation as a Tool for Approaching Technology and Communications to Preschool Students. *Voices from the Classroom: A Celebration of Learning*, 411.

[9] Department of Basic Education, in press, *introducing digital skills for all into GET: Curriculum framework grades R-9*, Department of Basic Education, Pretoria.

[10] DiSessa, A. A. (2018). Computational literacy and "the big picture" concerning computers in mathematics education. *Mathematical thinking and learning*, *20*(1), 3-31.

[11] Gilchrist J (2014) Evaluability assessment: developing a process to determine if a program is ready and able to be evaluated. Thesis. Simon Fraser University. URL: summit.sfu. ca/system/files/iritems1/14120/Gilchrist-capstone.pdf

[12] Grayson, T. E. (2017). Program evaluation, performance measures, and evaluability assessment in higher education. In *Handbook on measurement, assessment, and evaluation in higher education* (pp. 455-472). Routledge.

[13] Guo, P. J. (2017, May). Older adults learning computer programming: Motivations, frustrations, and design opportunities. In *Proceedings of the 2017 chi conference on human factors in computing systems* (pp. 7070-7083).

[14] Kaufman-Levy D, & Poulin M. (2003). Evaluability assessment: examining the readiness of a program for evaluation [Internet]. Washington, DC: Office of Juvenile Justice and Delinquency Prevention. Available from: jrsa.org/pubs/juv-justice/evaluability-assessment.pdf

[15] Lawson, C. A., Cook, M., Dorn, J., & Pariso, B. (2018). A STEM-focused program to facilitate teacher engagement before, during, and after a fieldtrip visit to a children's museum. *Journal of Museum Education*, *43*(3), 236-244.

[16] Leviton LC, Khan LK, Rog D, Dawkins N, Cotton D. (2010). Evaluability assessment to improve public health policies, programs, and practices. Annu Rev Public Health.;31:213-33. Available from: annualreviews.org/doi/full/10.1146/ annurev.publhealth. 012809. 103625?url_ver=Z39.88- 2003&rfr_id=ori%3Arid %3Acrossref.org &rfr_dat=cr_ pub%3Dpubmed

[17] Leviton, L. C., Khan, L. K., Rog, D., Dawkins, N., & Cotton, D. (2010). Evaluability assessment to improve public health policies, programs, and practices. *Annual review of public health*, *31*(1), 213-233.

[18] Lin DL, Harrison R. (2010) Evaluability assessment of a dental prenatal program. Canadian Journal of Dental Hygiene.;44(5):201-6. Available from: cdha.ca/ pdfs/Profession /Journal/ v44 n5.pdf

[19] Newcomer, K. E., Hatry, H. P., & Wholey, J. S. (2015). Using logic models. *Handbook of practical program evaluation*, 62.

[20] Public Health Ontario (2018). Evaluability assessment–a step model. Toronto, ON: Queen's Printer for Ontario.

[21] Pantic, M., Evers, V., Deisenroth, M., Merino, L., & Schuller, B. (2016, October). Social and affective robotics tutorial. In *Proceedings of the 24th ACM international conference on Multimedia* (pp. 1477-1478).

[22] Patton, M.Q. (2008). Utilization-Focused Evaluation (4th Ed.). Thousand Oaks, CA: Sage Publications.

[23] Shmatko, N., & Volkova, G. (2020). Bridging the skill gap in robotics: Global and national environment. *Sage Open*, *10*(3), 2158244020958736.

[24] Smith, M. F. (2013). *Evaluability assessment: A practical approach* (Vol. 26). Springer Science & Business Media.

[25] Thambu, N. (2017). Storytelling and story reading: A catalyst for inculcate moral values and ethics among preschoolers. *International Journal of Academic Research in Business and Social Sciences*, *7*(6), 1116-1130.

[26] Thurston WE, & Ramaliu A. (2005). Evaluability assessment of survivors of torture program: lessons learned. Can J Program Eval.;20(2):1-25. Available from: evaluationcanada.ca/ secure/20-2-001.pdf

[27] Trevisan, M. S., & Walser, T. M. (2014). *Evaluability assessment: Improving evaluation quality and use*. Sage Publications

[28] Wholey, J. S. (2004). Evaluability assessment. *Handbook of practical program evaluation*, *2*, 33-62.

[29] Williamson, B. (2017). *Big data in education: The digital future of learning, policy and practice*. Sage.

[30] Zandniapour L, JBS International. Impact evaluability assessment tool [Internet]. Washington, DC: Corporation for National Community Service; 2014 [cited 2017 Nov 24]. Available from: nationalservice.gov/sites/default/files/resource/Laying_the_Goundwork_ Before_Your_First_Evaluation_Tool.pdf

[31] Scratch (https://scratch.mit.edu/)

[32] htts://twitter.com/DBE_SA/status/1110084047672348673.

[33] www.facebook.com/Girlinrobotics)

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