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Interventions for Enhancing Indigenous Undergraduates' Programming Learning: A Systematic Review

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ABSTRACT

This study reviews the challenges faced by indigenous undergraduates in learning programming and identifies interventions to address them. A systematic review of 37 studies published between 2000 and 2022 found that Indigenous undergraduates face barriers to learning programming related to their indigeneity, motivation, mathematics anxiety, cognitive load, pedagogy, prior knowledge, critical thinking, and programming language anxiety. Interventions such as ethnoprogramming, culturally responsive pedagogy, ethnomathematics, and gamification have been proposed to overcome these challenges. Our review and analysis suggest that culturally responsive pedagogy and gamification show promise in improving indigenous undergraduates' programming learning outcomes. This study highlights the importance of designing effective interventions to support Indigenous undergraduates' learning and career opportunities in the global programming market. Future research could explore specialised interventions tailored to indigenous learners' unique needs and perspectives.

Keywords: learning programming, indigenous undergraduates, challenges, interventions, behaviour

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1 INTRODUCTION

Programming has been long regarded as a systematic issue in computer programming around the globe. When it comes to programming courses, it has a significant drop-out rate (Luxton-Reily 2016; Robins, Rountree & Rountree 2003). According to Watson & Li (2014), the percentage of undergraduates dropping out of programming courses is over 30% and more than 40% of undergraduates choose to decline the program itself, cued to Hublein (2014). For the past 20 years, the need for programmers has increased globally, and there have been considerable expectations for the potential of development as a primary source of economic development, especially in a third-world nation like Malaysia.

Programming courses have long been plagued by a high drop-out rate, making it a systematic issue in computer programming worldwide (Luxton-Reily, 2016; Robins, Rountree & Rountree, 2003). According to Watson & Li (2014), the percentage of undergraduates dropping out of programming courses exceeds 30%, while more than 40% choose to decline the program itself (Hublein, 2014). However, for the past 20 years, the need for programmers has increased globally, and there have been grand expectations for the potential of development as a primary source of economic growth, especially in third-world countries such as Malaysia.

Competency in programming is more valuable than ever, especially in the aftermath of the COVID-19 pandemic. COVID-19 has accelerated the shift to online first operating models, making working from home the new norm. While this has led to a recession in many fields, programmers are experiencing an expansion in opportunities. Pirani and Hussain (2019) suggest that programming skills are considered "gold dust" in the job market. Despite the skyrocketing demand for programming courses, there has been a massive drop-off in student enrolment and significant drop-out rates (Malik & Coldwell, 2017). This trend is driven by the lack of interest in programming and the alarming prevalence of subpar programming skills among undergraduates (Koularo et al., 2015). Another dominant reason for the high drop-out rate is that students with no prior background in computer or mathematics are often selected as computer science undergraduates, as government requirements for higher education prerequisites are loose (Muller et al., 2014). Therefore, it is not entirely fair to blame undergraduates for their lack of competence in programming courses.

It is common to read reports about Computer Science majors dropping out of their programs, and most of the reasons quoted are about the scope of the study, inability to cope with assignments, lack of motivation, behaviour, and inability to understand the language. For instance, Computer Science undergraduates throughout all institutions of technology quit during their first year of university or degree level, according to an Irish Times newspaper study in 2016. Most computer science professors agree that new students' inability to grasp the basics of their first programming language courses is a significant factor in their low success rates (Quille et al., 2015).

To meet global demand, the Malaysian government introduced STEM and STEAM, which became an integral part of Malaysia's computer science industry. According to Mustafa (2019), STEM was an approach to enhance active learning in programming. The Malaysian Ministry of Education

needs to prioritise acquiring science, mathematics, and coding skills. The Ministry of Education launched a "policy platform that involved the advertising and implementation of science, technology, the arts, and mathematics (STEAM) in 2015. To better prepare students for the challenges of the 21st century, these efforts were made.

Improved STEAM education is one of the ways to ensure that the STEM workforce and STEAM-literate citizens of the future are prepared for a highly technologically based society. Adding the Arts was motivated by Humanities and Social Studies and the need to foster creativity among all students (Baik et al., 2012). Students' low self-esteem and lack of enthusiasm for math and science, regardless of their academic success, is cited by the Organization for Economic Cooperation and Development (OECD) (2013) as a factor in the push to incorporate the arts into STEM education.

In addition, the "HOC" (Hour of Code) initiative, launched by the Malaysian Development Corporation (MDEC), has spread across the nation, encouraging students to learn computer programming through hands-on experience. The primary objective of implementing HOC was to ensure that all students could code. Students without access, native students, and students with a lack of understanding of mathematics and science are exposed to unplugged, a programme that teaches coding through games and actual manipulatives. These tactile options are strategically placed to aid students in assimilating complex ideas in ways that are relevant to daily life. About 1,200,000 students were exposed to coding (MDEC, 2019). By 2022, the figure had doubled. Yet even with execution, students continue to decline programming opportunities. Probable causes include economically deprived backgrounds, geographical drawbacks, mathematical failures, and even very little Internet connectivity. (Mohamad, Yeo, Abd-Aziz, and Rethinasamy, 2010). Many indigenous communities will remain impoverished and unable to support themselves if they do not have access to quality education. As a result, the educational gap will widen even further.

The effects of colonisation have a life-threatening impact on Indigenous communities across the globe. According to May & Aikman (2003), their formal education is under threat due to the implementation of "implicit & explicit" rejection of Indigenous knowledge and language. Meanwhile, St Denis (2011) argues that the national academic institutions have ignored the ethnocultural authenticity and indigenous knowledge due to western educational framework dominance and manipulation of non-indigenous values and philosophies. Wang & Gao (2013), on the other hand, argues that the lack of equal access to educational materials, inadequate training for teachers to cope with pluralism, stereotyping behaviours toward Indigenous students, and the absence of culturally sensitive curriculum, books, and pedagogy are considered major hindrances.

Most people in the indigenous community tend to work jobs that pay less. As a result of their geographic conditions, they typically engage in agriculture or fishing. It is also important to note that indigenous communities still lack infrastructure development, emergency or immediate availability of medical necessities, and educational opportunities for their children. Geographical isolation could be considered one of the most significant obstacles for the indigenous community. Even though most of them use smartphones, they accept that the advent of technology has invaded their lives by maintaining close relationships with migrant families. Despite all the promising facts about technology and ICT (Information and Communication Technology), compared to other promising development tools enabling individual choices and capabilities, a wide range of

different outcomes can be predicted. It is why many nations, including the United States, Australia, Canada, and nations with Indigenous communities, have prioritised providing quality education to all students and striving to improve the educational outcomes of Indigenous students. Despite numerous efforts to address this issue, Indigenous and non-Indigenous undergraduates still face disparities, particularly in computer programming courses. It has caused tension between traditional Indigenous worldviews and scientific knowledge (Resier et al., 2018). Indigenous communities are mostly excluded, and the gap must be bridged to achieve sustainability, considering the enormous development of technology and the pivotal role it has played in the pandemic's throes and growth. What begs the question is whether Indigenous undergraduates choose to drop out of school because they believe they are jeopardising their ethnic heritage, resulting in a decline in education. The article examines the findings of a systematic literature review conducted between 2000 and 2022. Indigenous undergraduates' views on programming and the views that prevent them from furthering their studies in STEM subjects, what most influential language or platform should be used to pique their interest, and what kind of interventions would be most effective were the studies' focus. A better understanding of what works and what does not would help future researchers and programmers make more informed decisions. The systematic literature review aims to provide a comprehensive overview of the topic and synthesise other researchers' ideas and findings into a single review.

1.1 Problem Statement

The field of computer programming is increasingly in demand globally, yet there is a lack of research examining the specific challenges that Malaysian indigenous undergraduates face when learning to code. It is particularly concerning as Malaysia continues to lag other nations in this area due to an approximately five-decade gap in technological advancements.

One major issue hindering the progress of indigenous undergraduates in programming is the educational gap in Malaysia. Rural and urban areas are characterised by significant educational disparities. The phenomenon means that students from indigenous backgrounds are more likely to face challenges when it comes to accessing quality education and opportunities to learn to program.

Another obstacle to indigenous students' learning programming is their cultural values, which may not prioritise education or may be incompatible with traditional forms of education. Furthermore, many indigenous communities continue to live in small, isolated communities and engage in subsistence activities like agriculture and fishing, which does not improve their socioeconomic status or provide them with the necessary resources to learn to program.

Given these challenges, it is crucial to investigate the specific problems that indigenous undergraduates face when learning programming and to identify interventions that can help bridge the educational gap and encourage more indigenous students to pursue programming. By addressing these issues, Malaysia can improve its economic prospects and reduce the number of indigenous students dropping out of university.

2 METHODOLOGY

2.1 Review Protocol – Barbara Kitchenham

The systematic literature review is based on Kitchenham's methodology as it is often used as a referring point in computer programming (Kitchenham & Charters, 2007). The methods of conducting a review were considered as they are widely publicised and based on prior well-established review methods in the computer science sector. The systematic literature review's initial stage is to inaugurate the detection and classification of the research question utilising Patient or population, Intervention, and Comparisons if there is any, and the type of outcomes that are of interest (PICO). A systematic approach for information retrieval was devised and implemented for identification, screening, and eligibility purposes. The goal of any good SLR (Systematic Literature Review) is to answer a specific research question by locating, selecting, and evaluating relevant studies (Dewey & Drahota, 2012). The systematic review should adhere to a clearly established protocol or plan in which the evaluation criteria are stated in advance. It is a complete, transparent search of many databases and grey literature that other researchers can repeat and reproduce. It entails planning a well-reasoned search strategy that has a specific focus or provides a solution to a stated question. The review specifies the categories of data that were sought, evaluated, and reported within specified time constraints. The review must include the search terms, search tactics (including database names, platforms, and search dates), and limits.

Table 1. Inclusion and exclusion criteria.

INCLUSION CRITERIA	EXCLUSION CRITERIA
Peer reviewed articles from 2000-2022	Duplicate publication
Research with at least 20 respondents (to reduce the bias that is related with a small sample size	Articles that do not reflect the link between indigenous undergraduates, education or learning programming
Studies that examine the link between indigenous community and learning programming.	Poster abstracts and written in other languages.
Studies focuses on challenges and interventions.	Studies that do not answer research question.
Studies on different methodologies.	Written in other languages

Inclusion and exclusion criteria set the boundaries for Systematic Literature Review. The criteria are predetermined before the search is conducted to avoid biasness. Different criteria are taken into consideration.

2.2 Formulation of the Research Question

Each article highlighted the challenges and interventions that could be used to overcome programming challenges. The reviewers have identified significant components in their review based on the existing theories, students' behaviour towards programming, teaching, and learning programming, and the interventions to work on the challenges.

Both traditional and automated screenings yielded articles that had been "snowballed", meaning that the shortlisted articles were deemed viable research and examined as per inclusion and exclusion parameters, which are applied.

Identifying the relevant keywords for a systematic literature review assessment has led to numerous attempts. A more extensive range of terms is constantly generated in an erratic set of materials, whereas too precise terms would often lead to a lack of relevant past research. The design of the previous research strategy was made to ensure that the search algorithm is consistent with what matches the answer to the objective questions that were only answered and included in the screening process. A combination of search terms that proved to cover the research topic was selected after some experimentation with several databases.

On the other hand, snowballing was carried out in specific ways (backward and forward). In this stage, the primary purpose was to broaden the possible pool of research literature by emphasising articles cited or cited by each initial research design of this study. After the selection procedure, backward snowballing was performed on a single predetermined depth before relevant cited papers were added during information extraction, enhancing the insight level.

2.3 Eligibility

To make sure the other articles met the set inclusion and exclusion criteria, whether through the scanning process, the article's title, abstract or full text. The results of 150 articles searches utilising different educational databases were generated. Through forward and backward snowballing, an additional 25 papers were identified from references of articles. After screening the titles and abstracts, 125 articles were considered ineligible because they did not match the inclusion requirements. The next screening of the other 55 articles revealed that 15 articles were identical. The eligibility and relevance of the rest 40 full-text publications for this systematic literature review study were evaluated, and 9 articles were discarded. Following this, 31 papers were extracted and incorporated into the systematic literature review.

2.4 Quality Appraisal

The quality appraisal process is conducted to guarantee that the research and evaluation of the reviewed articles have been done effectively. This systematic literature review uses the Mixed Method Appraisal Tool (MMAT). MMAT can be used to check systematic mixed studies review, which encompasses evaluating five types of research: qualitative, quantitative descriptive analysis, mixed method, randomised controlled tests, and non-randomised research. The quality of the

selected papers is evaluated using five fundamental parameters derived from the research methodology. MMAT's role is to highlight the prerequisites such as the suitability of research questions, the sufficiency of qualitative data analysis to identify the research question and their congruence between qualitative and quantitative, the data gathering process, analysis methods, and their relevance to each other.

Table 2. Search string and guidelines reviews.

Search Guidelines **Review insensitivity is not applied to search terms**	**Search Strings**	**Databases**
• Familiar terminologies are not used.	"Introductory programming" "Introduction to programming" "Programming Language" "Programming Challenges", "Programming trepidation", "Hardships in learning programming", "Interventions", "Overcoming programming challenges".	ACM IEEE Xplore ScienceDirect (Elsevier) SpringerLink Scopus ERIC OATD ProQuest
• AND is implied.	"Novice programming", "Novice programmers" "Learn programming", "Learning to program." "programming", "problem"	
• OR can be used to identify articles that include the keywords "learn programming" and "challenge," for example.	"Programming structure", "Programming nature", "Mathematical anxiety", "Fear of coding" "Teaching programming" "Learning Programming" "Computer programming" "Visual programming" "Natural Programming" "Iconic Programming" "First Programming Language" "Programming Education" "Student's behavior" "Student's attitude", "Indigenous programming", "Ethnoprogramming" "Indigenous community", "Aboriginal communities", "First nations", "Native education", "Indigenous education gap", "STEM education among natives", "Science education", "Western education", "Traditional education", "Indigeneity", "Inuit", "Native American", "Native Canadian", "American Indian", "Torres Strait Islander", "Māori People", "Pacific People", "Penan", "Orang Asli", "Negrito", "Senoi", "Kelabit".	
• Parentheses can be used to generate more sophisticated results, such as repository ((review article OR conferences) NOT theses)).	"Programming behavior" "Programming motivation", "Undergraduates' motivation", "Programming desire", "Programming difficulties", "Understanding semantics"	
• Enter a quotation sentence, such as "open access publishing".		
• To query for articles including "programming" or "programmers," or "indigenous education" use the * symbol in a phrase as a keyword, such as a programmer.		

Table 3. Programming challenges faced by indigenous undergraduates.

Challenges	Articles	Methodology	N	Key Findings
Indigenous Aspects	Cameron Lydster & Jason Murray (2018)	Qualitative	10	Pressing challenges included transfers from secondary to postsecondary education and a lack of academic readiness, including the absence of necessary academic literacy skills.
	Elisabeth Valmyr Bania et al., (2015)	Survey	4881	Geographical findings show that students' education is highly influenced by their society and culture, especially their parents, who are not educated.
	Bodkin-Andrews, G., Carlson, B (2014)	Observation	-	A higher rate of illiteracy and unemployment has been connected to racial prejudice by peers and educators when students make programming errors.
	Guo, P.J (2018)	Survey	840	Obstacles might be cognitive, emotive, or social. The increased cognitive burden and decreased comprehension that come from having to translate topics into one's home language in real time during a presentation are significant.
Undergraduates' lack of motivation.	Ya Shi Wan (2021)	Qualitative	59	Racial discrimination and non-educational challenges faced by the Indigenous undergraduates are often left unseen.
	Nikula, U., Gotel, O., and Kasurinen, J. (2011)	Case Study	157-249	The importance of intrinsic and extrinsic motivation in undergraduates' programming behaviour cannot be overstated. Intrinsic motivators are more likely than extrinsic motivators to do well in programming courses at the university level.
	A. Gomes and A. Mendes (2014)	Qualitative	18	Student performance will be lower if they lack motivation. Due to the obvious widespread perception that computer programming courses are difficult, this problem is sometimes exacerbated.
	A. P. Ambrosio et al. (2012)	Quantitative	72	In addition to tackling the algorithmic difficulty, students must deal with coding and compiling issues produced by the restriction of industrial programming languages.
	Robin et al. (2003)	Comparison Review	-	It has been a fundamental problem in programming subjects because novice programmers are perplexed by the language's complexity.

	Hendrik and Almed Hamzah (2021)	Systematic Review	-	Flipping classrooms would enhance the learning experience and offer students the necessary practice to become proficient programmers. During class, students in flipped classrooms tend to participate more actively.

Table 4. Interventions to overcome programming challenges.

Challenges	Articles	Methodology	Interventions	Key Findings
Indigenous Aspects	Laiti and Outi (2016)	Case Study	Ethnoprogramming	Ethnoprogramming is a programming method that leverages ethnic languages and understanding to help Indigenous students obtain a more explicit knowledge of computer programming through their native language.
	Linda L. Llewellyn et al., (2018)	Systematic Review	Culturally Responsive Pedagogy	Educators must design teaching practices inclusive of shifting undergraduate populations, recognising the need to identify and engage Indigenous undergraduates' cultural experiences.
	Meyer, S. & Aikenhead, G. (2021)	Systematic Review	Ethno-Mathematics	Teaching math in a way sensitive to different cultures could be a pivotal way to reach underrepresented minorities with lower success rates and higher drop-out rates than any other racial or ethnic group. It acknowledged the cultural heritage of underrepresented students to help them feel better about themselves and get them interested in math.
	Az-Zahroh,S et al., (2019)	Game Development	Gamification	ETHIC GAME (Ethnomathematics Game) is an augmented reality (AR)-based educational media that blends math and culture. Undergraduates can learn constructively by independently learning, watching, and listening to media.
Undergraduates' lack of motivation.	Selvarajah Mohanarajah (2018)	Quantitative	Gamification	Students' intrinsic desire to learn to program will be increased if they have access to the game's source code.
	Kapp (2012)	Experiment	Gamification	Gamification is a teaching strategy that uses gaming elements and visuals to pique students' interest and help them develop a more profound knowledge of computer programming concepts.
	Vidakis et l., (2020)	Game Development	Gamification	Using game-based learning strategies and educational concepts is a good fit because it encourages logical thinking.

	Strmecki et al (2015)	Experiment	-	Gamification helps undergraduates comprehend their programming requirements, reduce their cognitive load, and spike their motivation to work effectively in programming.
Pedagogical Interventions	Hendrik and Almed Hamzah (2021)	Comparison Review	Flipped Classrooms	Flipping classrooms would enhance the learning experience and offer students the necessary practice to become proficient programmers. In flipped classrooms, students are encouraged to participate more actively during class time and are given more hands-on coding assignments, which increases their interest in the subject despite their lack of prior programming experience.
	Luxton-Reilly et al. (2018)	SLR	Gamification	Gaming elements and visuals stimulate and enhance undergraduates' grasp of programming and slowly change their perception of programming, which is a significant hindrance.
	Vidakis et al., (2020)	Game Development	Gamification	Gaming promotes logical thinking and is a suitable match for educational ideas and game-based learning approaches.
	Strmecki et al (2015)	Experiment	Gamification	Studies have shown the effectiveness of gamification, and students can learn more efficiently when actively engaged in playing and learning.
	Stelio Xinaglos (2014)	Qualitative	Pseudocode	Instead of learning syntactic rules, pseudo-languages let students learn algorithmic and programming concepts and structures, allowing them to gain a deeper understanding of the fundamentals

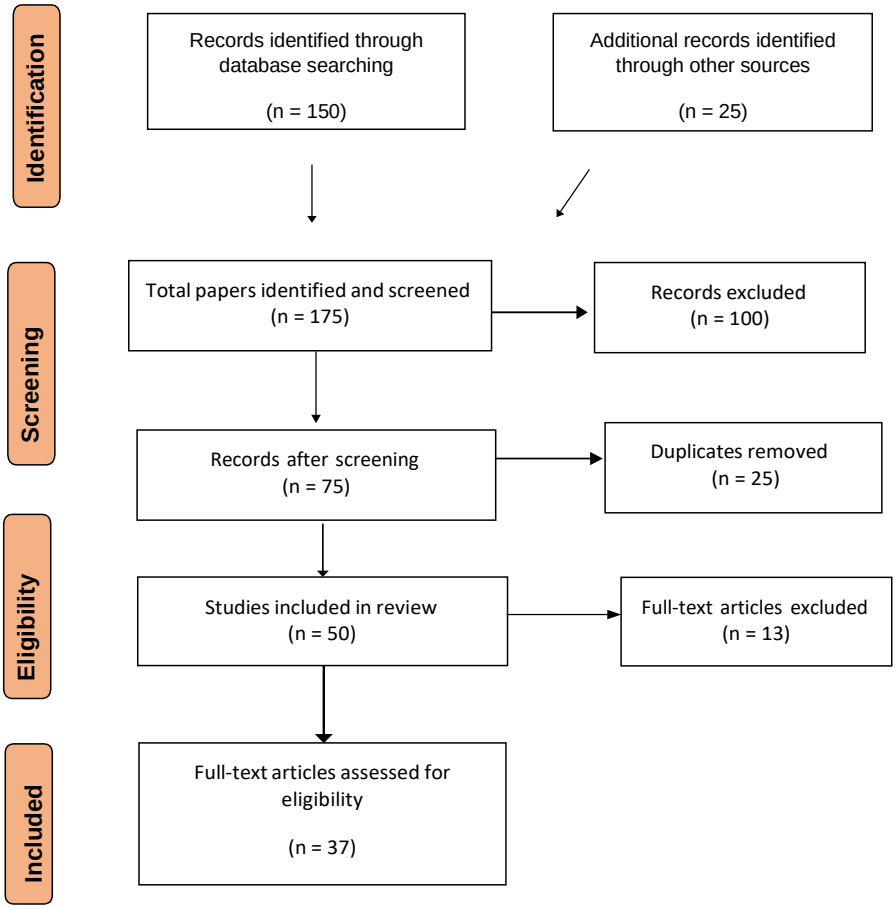

Figure 1. Flow diagram of the study ((Adapted from Moher et al., 2009).

3 FINDINGS AND DISCUSSION

3.1 Indigenous Parents' Perspective

The parents of indigenous students were particularly concerned about their children's ability to get to school (Ya Shin Wan, 2021). Non-educational hurdles included, but were not limited to, transportation issues, poor road conditions, and the distance between their homes and colleges. The problem of transportation security and dependability was also raised. As a whole, students' experiences with education are impacted by these difficulties. The parents' concern about physical access is a key issue. Despite JAKOA's practical challenges, the dread of parents and hassles disturb the quality of instruction for pupils. Waiting in line for public transportation is another big reason Indigenous students finally stop caring about going to school. Children whose parents take the initiative to drop and pick them up from school tend to go through a challenging time.

3.2 Indigenous Undergraduates Aspects

This review revealed a more significant understanding of what stops Indigenous students from learning programming throughout their tertiary education. The undergraduates find it hard to assimilate into the dominant society throughout their university life. The fear of losing the Indigenous identity, losing their connection to their communities, and being pressured to abandon Indigenous ways of thinking and behavior were major hurdles in attempting to fulfil their educational gap.

The fear of estrangement is a general apprehension regarding moving from home into a more extensive community. It is a fear of what if they are not accepted by the urban community or fear of how they would fit themselves in the environment. Putting their fear aside, the negative view of the non-indigenous undergraduates was also highlighted by the indigenous students. Severe racism and criticism were identified as barriers. What demotivates the Indigenous undergraduates is the latent institutional racism, especially by the educators. It happens due to the lack of respect towards other cultures and insensitivity.

It should be highlighted that the Indigenous community is living in a digitalised world, where Facebook reported 13.6 million Australian users in September 2014 compared to only 12 million in September 2013 (Cowling, 2014). Adolescents and young adults are considered high users of social media usage in comparison to other age groups of the community. Social media usage increases among the younger to young adults, and Facebook usage among the Aboriginal population is higher than the Australian population overall. These statistics by SBS Remote Australians Rely on Facebook to stay in touch (2014) prove that the Aboriginals are not left behind in digitalisation but only in education. The main challenge that should be addressed is changing their way of living. It could be argued that their values and traditions influence them to overlook the national plans and the significance of education. Their lack of interest in education has led to their poverty (Wan Afizi et al., 2013). The fact that most Indigenous parents do not care about their children's education has not changed in the intervening time. Indigenous parents who have not received an education expect their children to be the same (Abdul Razaq & Zalizan, 2009; Mohamad Johdi and Abdul Razak, 2009; Wahab, Mustapha & Talib, 2016).

Before jumping to conclusions on what important roles Indigenous identities play in academic research, it is vital to comprehend how education is used to spread fake information about Indigenous people. Most of the time, the Indigenous people have had the worst experience with educational policies, where they are not exposed to equal education (western education) and their behaviour towards education. Unintentionally discriminatory policies have led to lower achievement and isolation across several generations, as cited by Beresford (2019). It should also be brought to the limelight that Indigenous and non-Indigenous students have various levels of access towards education, which is still the same today. The educators' lack of empathy and understanding towards Indigenous students and their culture could be a probable reason the educational gap, especially in computer programming, still exists. Their existence and cultures were wiped off by implementing mainstream pedagogy and this was a step to abolish Indigenous cultural practices and values from living.

Another consequence of such education is the disruption of Indigenous people's traditional marginalisation, oppression, and discrimination (Graham et al., 2016). Parental fears about their children's education contribute to distrust and disconnection between children and educators (Kearney et al., 2014). According to Brown (2019), parents of Indigenous children may be reluctant to enrol their children in school because of their past and untold memories, and the wounds remain unhealed. It has the additional effect of causing Indigenous students to hide their heritage and conform to mainstream culture. Consequently, an increasing number of people only identify as Indigenous in adulthood.

Furthermore, the exclusion of Indigenous content from formal education, according to Nesterova (2019), causes Indigenous people to question the value of maintaining their cultures and knowledge, leading them to dismiss Indigenousness as unimportant at best. It also encourages the "Pan-Indigenous Lens" – the mutual political, social, and cultural perspectives that most Indigenous groups face while facing assimilation. Preserving beliefs and traditions in the face of the Indigenous community is a practical and necessary task.

Most indigenous undergraduates do not speak English fluently as their first language. They struggle with both humanities and computer programming. Students from indigenous communities face several cognitive and emotional social challenges, such as translating concepts from one language to another during lectures. They refrain from asking questions due to their inability to express questions verbally and their lack of familiarity with computer programming.

Indigenous students come from diverse cultural and linguistic backgrounds, speaking around 74 languages, and hailing from places within Sarawak. Many indigenous students participating in university courses cannot read in English. It could be considered the most significant obstacle. Indigenous undergraduates sometimes note that they must rely on English teaching materials or Google. This includes internet access to pedagogical resources such as textbooks, PDFs, forums, YouTube videos, and even lab demonstrations.

Translation to finish their assignments due to the difficulty of acquiring materials or source code in their local language. The fact that Indigenous undergraduates spend a considerable amount of time attempting to comprehend computer programming's technical jargon may be their most significant concern. Indigenous peoples face increased difficulty as a result. According to several studies' findings, most Indigenous students in university programs struggle when asked to visualise the concepts. Due to their low language comprehension, they require visuals or multimedia. Typically, they decide to drop out after a particular time.

3.3 Undergraduates Lack of Motivation

Intrinsic motivation is the driving force behind students' behaviour. Some undergraduates completed their programming projects, whereas most struggled, according to Nikula et al. (2011). Only a few students have the drive and ability to succeed in their course. In addition to intrinsic motivation, extrinsic influences affect the behaviour of undergraduates. Students are more likely

to enrol in a course if it is required for their degree than if they are really interested in it. The course's content complexity stifles this desire.

Many indigenous students who attend universities struggle academically because they are concerned about hygiene and their performance in computer programming classes. As the difficulty of the class increases, a greater percentage of students will drop out. It is" "tough to master" the required programming language, and "I have any acquaintances with whom to talk" Additionally, there are" "no books to refer to" The combination of this and the other students has an effect on one's motivation. Students who lacked the will to finish the course sometimes blamed their failure on issues with the language, expressed dissatisfaction with the experience, and ultimately dropped out, citing a problem with hygiene.

3.4 Mathematical Anxiety

Intrinsic motivation is the driving force behind students" behaviour. Some undergraduates completed their programming projects, whereas most struggled, according to Nikula et al. (2011). Only a few students have the drive and ability to succeed in their courses. In addition to intrinsic motivation, extrinsic influences affect the behaviour of undergraduates. If a course is required for their degree, students are more likely to enrol in it than if they are just interested in it. This desire is suppressed by the course's challenging material.

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All parts of programming terrify first-year computer science students. Istikomah et al. (2018) found that computer programming undergraduates showed high anxiety levels during their first lecture and when given software-related assignments. In this case, the authors claimed that anxiety relates to a curiosity about how programming or codes connect with mathematics learning; a lack of self-confidence to finish the task in a programming language; dread in presenting the assignments or given task; and worry of forgetting the procedures in performing the processes.

According to Zakaria and Nordin (2008), Indigenous undergraduates experiencing math anxiety had poorer exam scores. Keshavarzi and Ahmadi (2013) stated that arithmetic anxiety could spell doom for the computer programming sector. According to the study, math anxiety is more widespread among Indigenous undergraduates than non-Indigenous students. Indigenous undergraduates identified numerous causes for their math anxiety, including math's intricacy, difficulty, inability to perform well in high school math, math avoidance behaviour, and a lack of

effort compared to their last try. Concerns include a lack of familiarity with metropolitan academic environments and the absence of traditional family and cultural resources.

The fact that different mathematical concepts were covered and skipped over at various rates only made matters worse for the students. The attitudes and preconceptions of non-Indigenous students can have a considerable bearing on the degree to which indigenous students lack confidence in their numerical abilities. Math is challenging for indigenous students of any age or demographic, regardless of socioeconomic circumstances. As it is tedious, difficult to put into practice, and excessively abstract, many students find it challenging to learn.

Focusing on undergraduates' overall attitudes and perceptions of their mathematical abilities is also important. Math self-concept is the association between self and math. Past research focuses more math self-concept and stereotype threat is focused on gender differences. Girls tend to perceive their math ability to be less than their male counterparts. There are cultural, societal and gender implications for this biased self-concept of girls learning mathematics.

3.5 Cognitive Load

Cognitive load and academic achievement are well-researched. Most research focuses on first-year students. According to Das and S. R. (2020), students who perform poorly academically drop out of college in the first or second year. Universities are concerned with student performance and absenteeism. Academic achievement has been connected to a variety of cognitive qualities. Included are mental models, self-efficacy beliefs, motivation, and personality traits. It has long been known that student success is closely tied to their levels of self and drive. According to Talsma et al. (2019), self-efficacy is the most accurate predictor of academic performance. (Tsai et al., 2021). Everyone concurs that cognitively predicts academic performance. Every action begins in mind, according to the author.

In programming, there are various levels of activity and thought. Programming is made up of parts that interact with each other a lot, which makes working memory work harder. When teaching programming, some ideas require much thinking on their own. However, extraneous cognitive load can be reduced by changing how lessons are put together. It can help reduce the load on working memory or make it better by using sensory memory in the right way. Using sensory memory may involve showing pictures, which can help the working memory last longer because the pictures may not need to be processed by the working memory. When learning to code, you will need to use a lot of different skills at the same time or at various times. Sometimes, the skills you need at one time may be more than seven things, which is the limit of what you can remember in your working memory. Because of this, information is lost, and learning goals may not be achieved.

Adapting to new programming concepts is one of the most challenging components of learning how to code. Fundamental ideas such as variables and mathematics, selection and repetition, functions, and data structures are present in most starting languages. Grammar and use will be required for each of these. There are many challenging components of syntax to learn. Consider

the difficulty of setting up variables as an example. Students must use the matching keyword whenever a variable's data type must be stated before the variable is given in C, C++, or Java, for instance. Whenever the variable is used again in the future, its memory will be relocated to a different object. Before the students can learn to write their code, they must grasp this pattern modification. In addition to syntactic principles, the learner must understand how each new structure operates and what it can and cannot do. Both syntax and usage will enhance a student's cognitive load. When all these influences are present simultaneously, it is easy for a learner to become overwhelmed.

Indigenous undergraduates learn syntax and functionality in other subjects, such as math expression or English composition, but a beginner programmer must deal with more mental work. Beginners are not always able to overcome these early challenges. Learners frequently apply new programming structures to recent problems immediately after being shown how to use them. According to Sweller (1994), the task may be too difficult for the student if he or she cannot deal with the syntax and functionality of programming while also working on problem-solving. Students with prior experience with programming and problem-solving may find it difficult to see how cognitive load affects their performance in the classroom. It is because their experience allows them to avoid these issues.

Working memory is essential for students to encode the current information they acquire from sensory input. capacity to rehearse the material determines whether it is stored in long-term memory in working memory. Repetition of the information well enough to be stored in long-term memory following the current schema. A schema is organisational concept defining how the learner will perceive knowledge. When learning a schema, one's working memory becomes more efficient since it can handle more elements simultaneously.

According to cognitive load theory, working memory is affected by three types of cognitive load that come from the learning environment. Programming constructs and grammar, as well as the features of applying these items to specific problems, are all examples of intrinsic loads. This is an extraneous cognitive load when learner's mind is overworked by circumstances unrelated to the information they are absorbing. The requirement to look for similar problems or the sections of the problem description that students must comprehend before designing a solution is two examples of programming tasks that place an unneeded strain on students, as cited by Linn et al. (1992).

3.6 Pedagogical

Problem-solving skills and a shallow understanding of programs are two of the most common reasons students find it challenging to learn to program. It is common for undergraduates to approach programming line by line rather than employing effective, organised programs, according to Wu et al. (2018). It is proven that Indigenous undergraduates believe that programming is challenging and takes a lot of expertise, understanding, and ability to be learned at a very early stage (Mohamad et al., 2011). According to quoted research, most undergraduates in computer programming produce code without adequately studying, developing, and understanding the problem (Oroma et al., 2012). Because of their shaky approach to problem-

solving, undergraduates are unable to accurately perceive the problem, which leads to instances of plagiarism. In the worst-case situation, students either free ride on their classmates' work or wait for their instructors to give them leniency in the form of a grade boost.

The syntax and constructs of programming are likewise incomprehensible to newcomers. (Mohamad et al., 2011) For beginners, the three most common mistakes were syntax errors in basic programme structure, such as semicolons and curly brackets, problems in programme design or challenges with basic programme structure. Research found that students also make syntax errors in their code, such as failing to define variables and utilising faulty Boolean expressions (Qian & Lehman, 2019). The lack of familiarity with programming syntax means that novices cannot comprehend the compiler's debug error messages and hence cannot fix their program faults without the help of their friends or instructors. Learning a programming language's fundamental grammar, structure, and style should be an ongoing process for students. Loops, recursion, arrays, pointers, passing arguments, and abstract data types (Mhashi & Alakeel, 2013) were shown to be difficult for students to master. Despite the importance of theoretical lectures in acquiring programming, they emphasised that students require tutorials to comprehend how to put these concepts into practice before building software.

Poor learning style is another reason students have trouble learning to program. Everyone has a unique way of absorbing information. Some students prefer to join in group work, while others prefer to work independently. However, the most important thing is how students think, regardless of their learning style. Learning to program requires a new way of thinking, according to Rahmat et al. (2012). Researchers found that most people prefer to learn about something they are already familiar with rather than learn about something they are unfamiliar with. To put it another way, because many students feel that computer programming is a new subject, they have no prior knowledge or experience; grasping the concepts at first can be challenging. Rahmat et al. (2012) noted that most students lack the initiative to study programming and instead rely on their lecturers, acquaintances, or the internet to accomplish programming assignments without fully comprehending the task presented. It is consistent with their findings. While lecturers' notes, slides, and answer schemes are helpful for students just starting in computer programming, they are not enough for those just starting.

There is a severe shortage of programming language lecturers and instructors, particularly in the industry. The scarcity of trained professional educators in educational institutions affect students' motivation to see the connection between their studies and future employment (Oroma et al., 2012). Professors' lack of assistance influences students" interest in a programming class, particularly in teaching and learning methods (Jenkins, 2002). When the proper methods of instruction are not adequately presented, it is common for students to develop a learning style unsuitable for computer programming subjects. According to the study's findings, when students cannot follow the logic flow, they tend to memorise the entire coding.

Several issues stem from the instructor's lack of expertise and inability to communicate effectively with students (Xinogalos, 2016). Beginner Indigenous students have difficulty getting interested in computer programming since their teachers have difficulty teaching them the basics. To understand students" difficulties, instructors may not be able to see things from the perspective of

a novice. Students" misconceptions about the subject matter are made worse by teachers" inability to prepare pedagogical content knowledge, apply effective teaching tactics, and use appropriate teaching resources. According to Rahmat et al. (2012), computer programming challenges among students are further worsened by instructors" preparation of supporting content resources. Students from indigenous communities may have difficulty following the course materials because they are written in an unfamiliar language. Examples that are difficult to understand and exercises without answer schemes for students to cross-check their answers are just a few reasons why the programming class becomes boring or stagnant. The lecture slides, which are either taken or copied from the author's textbook slides without improvising them more comprehensively, are also a factor. Educators should play a significant role in disseminating the information and presenting the solutions to students, according to Gomes and Mendes (2007).

Another challenge with learning computer programming is the lack of relevant examples or real-world applications from instructors to students. There is a lack of satisfaction among students with the quality of input offered by teachers on the activities that are graded, according to Mhashi & Alakeel (2013). There should be enough feedback on tests, as well as examples of how to solve them, provided by instructors. As a result, the students will better grasp how the software operates. Students" knowledge and programming skills will be boosted by increasing the number of evaluations, selecting appropriate problems, and displaying the processes of solutions. In their study, Rosminah and Zamzuri (2012) found that students complained about the computer labs lacking hardware and software. To complete the assessment, students must purchase or rent online software for a set length of time. However, the assessments they submit are often of inferior quality or contain significant plagiarism.

3.7 Ethno-Mathematics

Ethnomathematics is an integral part of learning mathematics, which serves as the foundation for a society that refuses to accept disparity, inequality, and racial prejudice. Ethnomathematics is an excellent intervention due to its combination of culture and education. To reduce maths anxiety among Indigenous undergraduates, it is vital to utilise an alternative that encompasses their culture and use it to learn mathematics.

In the lives of Indigenous people, mathematics plays a central part in every aspect of daily life. According to math, the Indigenous people are not aware of their abilities and knowledge, according to Hermanto (2019). Geometry, based on mathematics, is used in their crafts and designs, proving that they use maths every day without even recognising it.

Ethnomathematics is a method for teaching math ideas relevant to the everyday life of Indigenous undergraduates (Balamurugan, 2015; Herawaty & Lubis, 2018; Rosa & Orey, 2011). An ethnomathematical method can serve as a bridge between both Indigenous and western knowledge. Ethnomathematics based on Indigenous tradition can affect the ways university students think about learning math (Widada et al., 2018). According to Rose and Orey (2011), ethnomathematics enables students to share math concepts that apply to their culture and daily lives can help them make more meaningful connections and increase their mathematical understanding. There are several ways to incorporate the indigenous way of life into mathematical education. Ensure that

all lessons are applicable to real-world situations"" Ethnomathematics assists students in overcoming their anxiety about mathematics while also widening their worldview (Supriadi et al., 2014).

Indigenous and non-Indigenous undergraduates can flourish academically, emotionally, and socially when they master math from an ethnomathematics perspective. Blending cultural values into education has taken various forms because of the various approaches and methods employed. Students can learn more and think more clearly if exposed to Indigenous culture in mathematics sessions (Widada et al., 2018). Ethnomathematics-based sociocultural learning allows students to practice mathematics in the classroom, which is superior to the approaches and is the most effective learning tool (Supriadi et al., 2014).

Teaching and learning variations are proposed to enhance students' understanding of ethnomathematics. It requires the incorporation of existing cultural artefacts (Mahmudah, 2021). Indigenous people have used them to view cultural objects and study mathematics closely. Learning variances can support individuals with varied qualities; therefore, this will assist students in understanding. Visiting learning artefacts can assist students in comprehending cultural history and determining which aspects are being utilised for math. So that students can reason mathematically, according to (Shigeo Katagiri, 2011).

Ethnomathematics, such as the maths of Indigenous community and cultures, has contributed to the usefulness of revolutionary geometry, according to Siemon et al (2019), who make the same argument for incorporating ethnomathematics into the teaching and learning process while teaching Mathematics. It is possible to teach Ethnomathematics in the classroom by introducing undergraduates to aspects of their cultural heritage that are relevant to mathematics. One way to bring ethnomathematics into the teaching process is to teach maths through the lens of how diverse cultures see the math.

D'Ambrosio's ethnomathematics notion refers to the third world and curricula development there. Indigenous people in the Arctic also have a point of view on ethnomathematics, although it is not universal. Yup'ik-based math education was explored by Lipka and Mohatt (2004), for example. According to his findings, he used ethnomathematics as the basis for his investigation. This man discovered the connection between Yup'ikk mathematics, nature, and conditions, mainly how to stay alive up north. It occurred to Lipka and Mohatt that the patterns in crafts may be applied in mathematics teaching and constitute a tool kit for mathematics. There are tales behind the patterns that can be taught, as well as geometry, fractions, algebra, and problem-solving skills.

An ethnomathematical approach to curriculum design helps students develop mathematical concepts and practises native to their cultures. Construction workers" unique mathematical knowledge was studied by Duarte (2004) through a study of the mathematical ideas and practises they develop on the job site. A teaching method known as ethnomathematics is used to explain the relationship between the cultural environment and mathematics while teaching. Progress in mathematics, science, and technology can be traced back to ethnomathematics in Japan and China today (Kurumeh, 2004; Uloko and Imoko, 2007).

3.8 Ethno-programming

Ethnocomputing encompasses both ethnoprogramming and ethnocomputing. Based on the concept that diverse cultures have distinct perspectives on programming, this is a method for making programming languages a more inclusive approach. There is research on Indigenous people with ICT, despite the lack of articles on making computer programming more suited for Indigenous people. Using the Four Directions project as an example, Bindler et al. (2002) investigated how technology is used in Native American classrooms. Researchers wanted to create a syllabus for Indigenous students that included their culture and language by using technology. The Indigenous community has always had doubts towards technology. From an Indigenous perspective, technology can maintain and destroy cultural identity and tradition. Considering gaming, social media, and technology are all ways in which young people are exposed to western society, indigenous people viewed western culture and education as a threat. Hence, implementing and exposing the indigenous community to ethnoprogramming is a way to overcome the challenges the Indigenous undergraduates face.

According to Darnell and Hoem (1996), Indigenous communities often compare the old and modern methods of doing things in daily life. Education and technology are being used to protect their cultural heritage from the enticing new options the Western world offers. According to the indigenous people, there are two opposing forces at work: their historical ties to the land and the modern norm that drives them to attend school and travel into urbanisation. Using this rationale, it is clear why the indigenous people need specialised education—learning programming according to their own cultural, linguistic, and educational traditions. Research by Laiti (2016), for example, shows how Sami Indigenous people can use producing crafts to learn to program. Sewing machines in programming are not a threat to Indigenous peoples because they are part of crafts.

3.9 Gamification

Gamification improves students" motivation by adding game aspects to the learning process (Dichev and Dicheva, 2017). While the primary goal of gamification is to increase students" abilities, it also serves as a tool for motivating them to study, increasing their motivation, increasing their retention of information, and encouraging positive behaviour changes. Researchers want to achieve levels of participation that are on par with what students can expect from a game.

Gamification allows students to learn by practising, which makes processes and results better in the long run (Shute & Ventura, 2013). Gamification allows individuals to learn independently and at their own pace. Students can monitor their progress through game-based learning (Klopfer et al., 2009), allowing for self-directed learning. Experimenting in a safe environment allows participants to fail without fear of repercussions. While playing a video game, students may feel various emotions, including a sense of amazement, a sense of intrigue, and a sense of sheer joy without being judged or discriminated against. Hence this allows the students to learn and perceive programming in a fun and engaging setting, which would slowly impact their education.

According to the research, particular game elements are required for gamification. Rewards, challenges, and leader boards all fall under gamification (Hamari, Koivisto & Sarsa, 2014; Hanus & Fox, 2015). Learners can tackle challenges in an engaging and enjoyable approach by using gamification and other kinds of gaming tactics. It is possible to boost the average recall rate of knowledge up to 20 times by using gaming aspects rather than lecturing about it (Cook, 2013). In the world of gamification, experts advise educators not to implement a gaming mechanic into a classroom and expect favourable results. Feasible goals and rules that encourage involvement and feedback are essential to the success of game mechanics (McGonigal, 2011).

Learning through gamification is a relatively new trend. It tremendously impacts how students are educated and how they learn. Students that participate in game-based learning are more engaged and motivated. In addition, it helps students" study and understand a challenging subject. Past researchers have taught students the basics of computer programming using gamification techniques was one of the attempts. It is a game-based learning methodology in which students play and assess games, present, demonstrate, and create new games. The use of games in education aids learning and retention, but this demands an expert educator to design games that incorporate principles and processes. It can be utilised in the learning process effectively, as cited by Elsiekh et al., (2017).

3.10 Pseudocode

Developing a viable computer programming project can take a long time for undergraduates what a program or algorithm should perform, articulated in formally styled natural language rather than a programming language. An essential part of the development of a program is the use of pseudocode. Using pseudocode, the separate steps of an algorithm can be described in a way that even someone with only the most fundamental programming skills can comprehend. Even though pseudocode is a non-syntactic representation of codes and algorithms, moving from pseudocode to implementation should require that each line be translated into code using the syntax of any programming language available. As a teaching tool, pseudocode can be used to explain the fundamentals of the codes to Indigenous undergraduates, which will aid their comprehension. To make programming more approachable for Indigenous students, pseudocode facilitates code building, turning plain-language instructions into executable code written in any programming language.

4 IMPLICATIONS & RESEARCH GAPS

In this review, a wide range of themes, including behaviour, perception, prior knowledge, and Indigenous aspects, were identified, resulting in a clearer picture of the concepts; however, it was quickly recognised that most articles, particularly in Urban, were centred on nonindigenous undergraduate perspectives.

Although researchers have discovered a huge educational gap between Indigenous and non-Indigenous communities, relatively little research has been conducted on Indigenous populations

and the challenges they experience when learning computer programming. Indigenous scholars have more excellent knowledge and solutions for addressing these obstacles, which could contribute to closing the gap.

In addition to researchers, school instructors and non-governmental organisations (NGOs) such as Teach for Malaysia, KOMAS, and the government can promote and implement culturally relevant pedagogy, ethno-STEM, ethnomathematics, and Ethnologues, to attract Indigenous people. Frequently, the research results of outsiders are biased towards their own point of view or the demands of western Indigenous peoples, as opposed to an Asian one. Putting aside the Western perspective on Indigenous education, more study should be performed from the inside rather than the outside. By performing the study, it will be more connected to the community and aware of the genuine educational needs of the Indigenous population.

Future research can investigate more dimensions to increase our understanding of the problem. With different themes being associated, researchers can investigate integrating them depending on their potential utility to advance Indigenous education knowledge. However, it is essential to note that additional socially relevant themes, such as governance and supervision, may be included in the field of study in the coming years.

5 RESEARCH REGION

The representation of research samples of challenges in learning programming is unbalanced worldwide. Previous studies assumed that the issue of Indigenous peoples and education was only getting exposure in first-world countries. According to the World Bank Group (2016), the education gap is a worldwide concern that does not only affect western countries.

The involvement of Indigenous communities in computer programming is predominantly centralised in first-world countries, particularly in western countries. Indigenous people make up 150 million, or one-fourth of the world's indigenous population, and their participation in programming studies is low. Many previous studies have also revealed that sociocultural disparities play a significant role in computer programming learning. Asian countries should be included in the discussion. There is an urgent need for more research results and data from Asian countries.

6 THEORETICAL GAP

It would be beneficial if scholars could incorporate various theories and concepts into their research (Whetton, 1989). Only 26 theory-oriented papers were evaluated in the systematic literature review, and the use of multiple theories was also found to be rare. Since the difficulties faced by Indigenous undergraduates in learning programming are a critical constraint, researchers believe that comprehension and evaluating the situation necessitates the use of theory. Future research should consider other theories to study behaviour in addition to the theory of planned behaviour, theory of constructivism, social learning theory, socio-constructivism, situated learning

theory, and community of practice. Stern's (2000) value-based norm theory could also be instrumental in future research.

7 METHODOLOGICAL GAP

Although current methodological approaches to research have catered for various techniques and analyses, this systematic literature review suggests incorporating new interventions and using Artificial Intelligence and Machine Learning can be easily implemented in future work. By incorporating machine learning and artificial intelligence in the workplace, researchers may reduce their workload.

8 LIMITATIONS

This systematic literature review shed light on the current state of learning programming challenges. To uphold the review's reliability, only English-language journal articles from databases were considered. As the scope of current SLR is limited to challenges faced by Indigenous undergraduates and interventions to overcome them, the research objectives will be met. As a result, this could be viewed as a steppingstone to greater adventure.

9 CONCLUSION

Many students, especially Indigenous students, find it challenging to learn how to code. Undergraduates frequently drop out of programmes or courses, and students who attempt to learn programming have a high failure rate. This systematic review aims to identify and address the issues that Indigenous undergraduates experience in their undergraduate courses. Math anxiety and prior knowledge are considered as well as factors such as motivation and cognitive load.

Interventions are highlighted in this study; despite the challenges it addresses being comparable to those previously studied. Cultural, inclusivity, and pedagogical considerations were all brought up. It is clear from this study's findings that Indigenous undergraduates encounter considerable academic and non-academic difficulties that hinder their progress. As most research focuses primarily on programming difficulties, this review focuses on Indigenous students and solutions that combine science and Indigeneity on a large scale.

To deal with the problem and create a workable solution, it is necessary to gain a better understanding of the linkages that can be formed between Indigenous knowledge and computer programming, which may not be readily apparent in their daily lives.

Future researchers should consider implementing a few aspects to understand the issues better, such as conducting an experiment, use qualitative research as the primary mode of inquiry, or operationalise a mixed-method approach. If a survey is used, researchers should Develop a questionnaire with a 7-point Likert scale to be extra precise, faster, and easier to use, and a good

accurate representation of the proper evaluation of a respondent. More research is required to refine the proposed intervention into a more sophisticated one.

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