Impact of Implementing Critical Thinking Method in Teaching Programming Languages

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ABSTRACT: This paper reviewed and assessed the impact of using critical thinking in teaching programming languages Adoption in the Sudanese Higher Educational Institutes in Khartoum state, Sudan from the instructors' point of view and/or perceptions. Moreover, the paper presented the roles and reasons for adopting critical thinking including the challenges and issues faced by the instructors.

This paper used descriptive statistics and theoretical analysis approaches for collecting and analyzing the data. The investigation was based on a qualitative and quantitative design using questionnaires and semi-structured interviews. The research questionnaires were distributed to four hundred (400) possible respondents over ten (10) selected Sudanese Higher Educational Institutes (SHEI) in Khartoum State with only two hundred fifty-five (255) usable questionnaires, yielding a response rate of sixty-three percent (63%). Questionnaires focused on the five (5) measures elements of critical thinking (CRE) namely: analyzing, information seeking, logical reasoning, determining relevance, and research.

The results of the analysis of the variance between the five (5) independent variables of the (CRE) and the status of the (SHIE) showed that the measures of elements were not fully implemented in teaching programming language techniques in the Sudanese Higher Educational Institutes in Khartoum state, Sudan. Thus, it is recommended that the elements be fully incorporated in the design of the Critical Thinking Adoption (CRA) in teaching programming language techniques before it is provided to the students and stakeholders.

KEYWORDS: Critical, Thinking, Sudan, Future, University, College, Adoption, Analysing, Information, Seeking, Logical, Reasoning, Relevance, Research, Salah, Hassan, Malik, Information, Technology, Programming, Language.

INTRODUCTION

Sudan, officially the Republic of Sudan, is a country in Northeast Africa. It shares borders with the Central African Republic to the southwest, Chad to the west, Egypt to the north, Eritrea to the northeast, Ethiopia to the southeast, Libya to the northwest, South Sudan to the south, and the Red Sea.

Sudanese universities and colleges are public and private education systems inherited by the government after independence and were designed more to provide civil servants and professionals to serve the colonial administration than to educate the Sudanese, the vision is to participate, through its role in the field of higher education and scientific research, in the creation of a unified, developed and advanced Sudanese Nation and aspires to be independent both academically and financially, elevated in the different aspects of knowledge and to link the programs and research they offer with the requirements of permanent development in Sudan.

The use of the term 'critical thinking to describe an educational goal goes back to the American philosopher John Dewey (1910), who more commonly called it 'reflective thinking. He defined it as active, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it, and the further conclusions to which it tends. (Dewey 1910: 6; 1933: 9) and identified a habit of such consideration with a scientific attitude of mind. His lengthy quotations of Francis Bacon, John Locke, and John Stuart Mill indicate that he was not the first person to propose the development of a scientific attitude of mind as an educational goal.

In the 1930s, many of the schools that participated in the Eight-Year Study of the Progressive Education Association (Aikin 1942) adopted critical thinking as an educational goal, for whose achievement the study's Evaluation Staff developed tests (Smith, Tyler, & Evaluation Staff 1942). Glaser (1941) showed experimentally that it was possible to improve the critical thinking of high school students. Bloom's influential taxonomy of cognitive educational objectives (Bloom et al. 1956) incorporated critical thinking abilities. Ennis (1962) proposed 12 aspects of critical thinking as a basis for research on the teaching and evaluation of critical thinking ability.

The definition of critical thinking in educational contexts is a "programmatic definition" It expresses a practical program for achieving an educational goal. For this purpose, a one-sentence formulaic definition is much less useful than the articulation of a critical thinking process, with criteria and standards for the kinds of thinking that the process may involve.

The real educational goal is recognition, adoption, and implementation by students of those criteria and standards. That adoption and implementation in turn consists in acquiring the knowledge, abilities, and dispositions of a critical thinker (Scheffler 1960: 19) Critical thinking an educational program that is aimed at developing critical thinking but not the correlative disposition to care about the dignity and worth of every person, he asserted, "would be deficient and perhaps dangerous" (Ennis 1996: 172).

Critical thinking has the power to launch students into unforgettable learning experiences while helping them develop new habits of thought, reflection, and inquiry. Developing these skills prepares students to examine issues of power and promote transformative change in the world around them.

Programming language is any set of rules that convert strings, or graphical program elements in the case of visual programming languages, to various kinds of machine code output. Programming languages are one kind of computer language and are used in computer programming to implement algorithms. A programming language is a computer language programmers use to develop software programs, scripts, or other sets of instructions for computers to execute. Although many languages share similarities, each has its own syntax. Once a programmer learns the language's rules, syntax, and structure, they write the source code in a text

editor or IDE. Then, the programmer often compiles the code into machine language that can be understood by the computer. Scripting languages, which do not require a compiler, use an interpreter to execute the script (Computer Hope,2021).

1. ***Reasons for using Critical Thinking:***
   - ***An Activity for the mind:*** *Just like our muscles, in order for them to be strong, our mind also needs to be exercised and challenged. It's safe to say that critical thinking is almost like an activity for the mind — and it needs to be practiced. Critical thinking encourages the development of many crucial skills such as logical thinking, decision making, and open-mindless.*
   - ***Enhances problem-solving skills:*** *Critical thinkers enhanced problem-solving skills make them better at their jobs and better at solving the world's biggest problems. Like Einstein, they have the potential to literally change the world.*
   - ***Allows for creativity:*** *Critical thinkers are also highly creative and see themselves as limitless when it comes to possibilities. They are constantly looking to take things further, which is crucial in the workforce.*
   - ***Better decision-making:*** *There's no doubt about it — critical thinkers make the best choices. Critical thinking helps us deal with everyday problems as they come our way, and very often this thought process is even done subconsciously. It helps us think independently and trust our gut feeling.*
   - ***Form well-informed opinions:*** *There is no shortage of information coming at us from all angles. And that's exactly why we need to use our critical thinking skills and decide for ourselves what to believe. Critical thinking allows us to ensure that our opinions are based on the facts, and help us sort through all that extra noise.*
2. ***Challenges in using Critical Thinking:***
   - ***Egocentric nature and thinking patterns****: Egocentric nature or behavior is a natural tendency and is many a time difficult to overcome. Such a barrier is making the person think about himself and leads to the inability to not to sympathize with others to understand their issues and problems.*
   - ***Group Thinking:*** *Group Thinking is yet among the harmful Barriers to Critical Thinking, plus it is also quite unhealthy.*
   - ***Drone Mentality:*** *The drone Mentality barrier can be explained as when a person doesn't pay attention during important work meetings and discussions.*
   - ***Social Conditioning:*** *Many of us have a habit of thinking within our comfort zones, and we refrain from even thinking outside our spectrum as we are taught to think in a certain way and manner owing to the various social conditions.*
   - ***Biased nature and experiences:*** *Having a personal bias is one of the biggest Barriers to Critical Thinking as its curbs and prohibits a person from making decisions that are fair, open-minded, and transparent.*

THE PROBLEM

Despite the growing literature in the area of Critical Thinking and Programming Language Technique, it is not known why the adoption of the Critical Thinking Method in Teaching Programming Language is still very slow, especially in Sudanese Higher Educational Institutes (SHEI). Could it be a reflection of the fewer acknowledgments for the roles and importance of the Critical Thinking Method ***(CRM)*** *in teaching programming language in Sudanese Higher Educational Institutes (SHEI)?*

Based on the problem raised the following hypothesis was raised: " ***The Performance of Implementing Critical Thinking Method in Teaching Programming Language influences by the Critical Thinking Elements****".*

RESEARCH MODEL

*The following research model (Figure1) was developed based on the effect of the five independent variables of the Critical Thinking Elements (CTE) in the Sudanese Higher Educational Institutes (****SHEI****) identified in the literature in order to assist the study in answering the above question.*

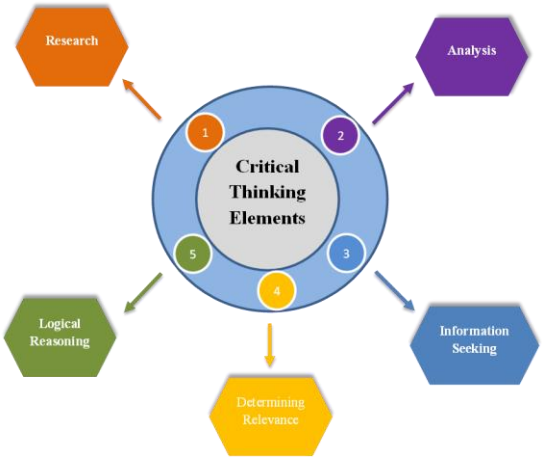

Figure 1 CTE Research Model

LITERATURE REVIEW

This section provides a review of the conceptual literature which will inform the frameworks of the study. The literature review for the study includes the definition of the terminologies used in the study such as Critical thinking, Computer Programming Language, Cronbach's Alpha, Quantitative data, Reliability Testing, Data Suitability, Kaiser-Meyer-Olkin Test, Bartlett's Test of Sphericity, each of these themes contributes to the foundation for this study.

1.1 Critical thinking

Critical thinking an educational program that is aimed at developing critical thinking but not the correlative disposition to care about the dignity and worth of every person, he asserted, "would be deficient and perhaps dangerous" (Ennis 1996: 172).

1.2 Programming Language

A programming language is an artificial language that can be used to control the behaviors of a machine, particularly a computer. Programming languages, like human languages, are defined through the use of syntactic and semantic rules, to determine structure and meaning respectively. Programming languages are used to facilitate communication about the task of organizing and manipulating information, and to express algorithms precisely. Some authors restrict the term "programming language" to those languages that can express all possible algorithms; sometimes the term "computer language" is used for more limited artificial languages.

1.3 Quantitative data

Quantitative data are used when a researcher is trying to quantify a problem or address the "what" or "how many" aspects of a research question. It is data that can either be counted or compared on a numeric scale. (Wikipedia, Mar 9, 2021).

1.4 Cronbach's Alpha

Cronbach's alpha is a measure of internal consistency, that is, how closely related a set of items is as a group. It is considered to be a measure of scale reliability. A "high" value for alpha does not imply that the measure is un-dimensional.

1.5 Reliability Testing

Refers to the extent to which a test measures without error. It is highly related to testing validity. Test reliability can be thought of as precision; the extent to which measurement occurs without error (John DeLuca, 2021).

1.6 Data Suitability

Data suitability focuses on data characteristics that can assist in summarizing researchers' data needs and mapping the research needs to the data provided. To standardize suitability assessment, this study contributes an original conceptual framework that applies to observational studies (Oxford, Sep 8, 2017).

1.7 Kaiser-Meyer-Olkin (KMO)

The Kaiser-Meyer-Olkin (KMO) Test is a measure of how suited your data is for Factor Analysis. The test measures sampling adequacy for each variable in the model and for the complete model. The statistic is a measure of the proportion of variance among variables that might be common variance. The lower the proportion, the more suited your data is to Factor Analysis (Yadolah Dodge, 2010).

RESEARCH METHODOLOGY

Descriptive statistics techniques are used to analyze the data. The questionnaire technique of data collection will be used. Instructors from ten (10) Sudanese Higher Educational Institutes (SHEI) (Future University, Sudan International University, Khartoum University, Nile University, Sudan University, Ibn Sina University, Musharieg University, Al-Mogtarbien University, Al-Bayan University, and Garden City University) in Khartoum state will be conducted purposively to select the participant of the questionnaire. Analysis of variance (ANOVA) will be used to answer the research question, the sampling frame population for the paper was 600 persons. Even though 400 questionnaires were distributed to the participants, only 255 questionnaires were successfully collected. Of the 255 (63%) questionnaires that were returned successfully only 150 (59%) copies were completely answered. The remaining 105 questionnaires could not be included in the study due to incomplete data or poor responses.

RESULTS AND DISCUSSIONS

Multiple regression analysis techniques were used as a Quantitative approach to answering the question about the status of the adoption of the critical thinking method in the programming language in the Sudanese Higher Educational Institutes from the instructor's point of view.

The purpose of multiple regression analysis is to help the researcher understand the association between more than two quantitative variables. In order to identify the association of the independent and dependent variables, a multiple regression analysis was carried out. The regression equation is: $\mathbf{Y=\square_0+\square_1X_1+\square_2X_2+\ldots+\square_pX_k+\square\square\square\square}$ *where Y is the dependent variables (X1, X2, Xk) is the k independent variables,* $\square$ *is the error term, and* $\square_0, \square_1, \square_2, \ldots, \square_k$ *are the regression coefficients.*

There are four principal assumptions that justify the use of regression analysis for the purpose of prediction: Linearity of the relationship between dependent and independent variables; Independence of the errors (no serial correlation); Multicollinearity and Normality of the error distribution (Field, 2005).

Table: 1.1: Results of Regression Model Analysis between Independent Variables and Dependent Variables.

Variable	***B***	***Std. Error***	***Beta***	***T***	***Sig.***	***VIF***
Constant	***2.9E-016***	***.067***		***.000***	***1.000***	
Analysing ing	.401	.069	.235	6.452	.000	1.112
Information Seeking	-.001	.071	-.001	.055	.741	1.197
Logical Reasoning	.311	.053	.321	4.333	.003	1.073
Determining Relevance Resources	.063	.051	.065	1.207	.158	1.154

Research Environment	.0621	.071	.081	1.063	.263	2.242

(Table 1.1) shows the results of multiple regression analysis between analyzing, information seeking, logical reasoning, determining relevance, and research and perceived use of Critical Thinking Elements in Teaching Programming Language. The adjusted squared multiple correlation coefficient (adjusted R2) clearly explains 29% of the variance associated with the perceived use of the Critical Thinking Elements, (see Table 1.2). The F statistic is also significant (F = 7.111) (see also Table 1.2) which confirms that not all the variables make a significant contribution to fit into the regression model. Four independent variables, namely analyzing, logical reasoning, determining relevance, and research were found to be significantly associated with the perceived use of the Critical Thinking Method in Teaching Programming language in Sudanese Higher Educational Institutes, Khartoum state, Sudan.

As can be seen in (Table 1.1), the usage depends only on analyzing, logical reasoning, determining relevance, and research. The term 'Multicollinearity' has been coined to express the situation where the independent variables are higher associated with each other. The last column in (Table 1.1) shows that the highest VIF (Variance Inflation Factor) value is 2.242 *which is below 5 and therefore there is no problem with Multicollinearity (Hair et al., 2006). Thus, the predictor variables can be considered to be independent of each other. In (Table 1.2) the p-value is less than 0.001; Therefore usage depends on at least one of the predictors. The R-squared value is 0.711, which means 29% of the variation in usage can be explained by all 5 predictors.*

Table 1.2: ANOVA Table

Source	***Sum of Squares***	***Df***	***Mean Square***	***F***	***Sig.***
Regression	*044.542*	*008*	*6.361*	*7.111*	*.000(a)*
Residual	*203.458*	*248*	*.801*		
Total	*248.000*	*255*			

R2= .231, F = 7.111

FINDINGS

The findings from this study revealed that a key among the challenges associated with the implementation of critical thinking methods in programming languages there is a lack of Information Seeking. Furthermore, analyzing, logical reasoning, determining relevance, and research were among the key strategies which the respondents felt should be put in place to improve the implementation of critical thinking methods in teaching programming language in Sudanese Higher Educational Institutes (SHEI).

CONCLUSIONS AND RECOMMENDATIONS

*Critical Thinking Methods (**KTM**) offer very powerful instruments to bring higher performance to teaching programming language. However, as it has been stated in several studies reviewed, the Critical Thinking Method (**CTM**) is not a solution to any development problem; it provides an opportunity. This research paper explores the experience resulting from these attempts worldwide; and implies the same practice in the growth of Critical Thinking in the Sudanese Higher Educational Institutes with a focus on the potential role of programming languages to enhance effectiveness, efficiency, and management of overall teaching methods. The findings from this study should enable top management in the Sudanese Higher Educational Institutes to implement proactive approaches to improve critical thinking method adoption in order to improve the performance of teaching programming languages techniques.*

*The Limitations of this study is the participant of our questionnaire survey conducted within a specific Sudanese Higher Educational Institutes or participants, the results of the study therefore may not be generalized to all other Sudanese Higher Educational Institutes (**SHEI**), the study was conducted only for specific Sudanese Higher Educational Institutes in Khartoum State, Sudan, the results may not be more accurate to all other Sudanese Educational Institutes.*

*Challenges for implementing the Critical Thinking Method in the Sudanese Higher Educational Institutes (**SHEI**), and teaching style includes: analyzing, logical reasoning, determining relevance, and research in term of teaching programming language.*

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