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EXPLORATORY STUDY OF THE APPLICATION OF THE TYLER OBJECTIVES-CENTERED MODEL FOR THE EVALUATION OF THE LEARNING EXPERIENCE

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ABSTRACT

The current study focuses on the evaluation of the learning experience based on the Tyler objectives centered model. The first part of the study is the development of the evaluation approach and the second part is the application of the developed evaluation approach. The development of the evaluation approach was successful for an exploratory study; however, the fifth step of the evaluation approach requires a further study. The current study's data was insufficient for the application of the approach; hence the application was incomplete. The advantages of the developed evaluation approach are: i) the approach is applicable to all curriculums that have objectives, ii) it has an allowance for evaluators to innovate new methods along the six steps for the approach to best suit their particular situations, and iii) it is easy to apply the approach. On the other hand, the disadvantages are: i) it might not work when the data is insufficient and ii) to some evaluators that are not willing to be creative in step 5, the approach might be suitable for them after the future study that will provide details for step 5. In the future study the two disadvantages will be prioritized, for the efficiency of the evaluation approach.

KEYWORDS: *Model, learning experience, curriculum and evaluation*

1. INTRODUCTION

According to Hunkins and Ornstein (1988), they define curriculum evaluation as a process that mainly depends on collecting and combining data in order to allow people's judgements about pre-determined goals or scales. In 1997, Kaya defined curriculum evaluation as the collection, analysis and interpretation of the data for the purpose of judging the curriculum effect, effectiveness and all the outcomes (Kaya, 1997). Fox and Hackerman (2003), state that curriculum evaluation process is more methodological than content specific. They define it as a continuous effort to examine the impact of an operational content and procedures to attain pre-determined goals. Curriculum evaluation is one topic that is slowly becoming a central part in the development of the curriculum, for the purpose of ensuring its effectiveness (Danju, 2017). Hence, there is a gradually increase of scholars who adopt curriculum evaluation models that emerged between the years 1970 – 1980. In the year 1971, the Stufflebeam model was developed, this model mainly focused on producing an evaluative data for decision making (Stufflebeam, 1971). In 2018, the Stufflebeam model was adopted for application to various branches of the Welfare school system in Rawalpindi, a city in Pakistan. It found satisfactory learning experiences; however, teachers were found to be prioritizing rote learning and theoretical work. Those were found to impact students negatively because their intellectual abilities become limited (Aziz et al, 2018). In 1972, Michael Scriven proposed a goal-free model (Scriven, 1972). Scriven's goal-free model focused on the effects of the curriculum rather than on its objectives and goals. In the recent years, Scriven's goal-free model gradually received recognition. Some researchers noted that the concept of "goal-free evaluation" was adopted by various scholars in their own developments (Youker, 2013 and Zurqoni et al, 2018). In 1975, a responsive model was introduced called Stake Model. This typical model imposed that the concerns of the evaluated participants should be a priority (Stake, 1975). The study of Wood (2001), found the Stake model to be effective when it was applied on the environmental education professional development course. On the other hand, Dewantara (2017) recommended that the model be applied to larger sample sizes for meaningful evaluation results.

Regardless of the numerous studies, curriculum evaluation would always remain a necessity (Khalid et al, 2011 and Khalid et al, 2012). Hence, there is a need for an effective approach that will facilitate satisfactory attainment of curriculum objective(s) (Rugakingira and Onyango, 2022). To contribute to the available literature, the current study adopted Tyler's objective-centered model with an aim to implement an evaluation approach of curriculum objective(s) attainment through learning experiences. In that regard, our study is attempting to answer the following question: How could the Tyler's objective-centred model be developed to evaluate a curriculum's objectives attainment learning experiences?

2. METHODOLOGY

2.1 Tyler Objectives-Centered Model

Ralph Tyler is one of the scholars who aimed to establish a set of rules to guide teaching and learning. He proposed a curriculum design that was systematic and sequential. For this reason, the model that he developed is mostly referred to as the 'Linear Objectives' model (Ibehi, 2021). The model primarily focuses on analyzing, interpreting, and explaining the curriculum and instructional program in four simple steps (Tyler, 1949). The model begins with the selection of the curriculum objectives, follows with the selection of learning experiences, furthermore the organization of learning experiences and concludes with evaluation of learning experiences as shown in Figure 1. The first step of the Tyler model, is the selection of curriculum objectives. His recommendation was that the curriculum planners should identify general objectives by collecting data from the following sources: contemporary life outside the school, the subject matter and the learners (Tyler, 1949; Ibehi, 2021). The second step of the model, is the selection of the learning experiences. Tyler defined it as the interaction between the learner and the external conditions in the environment to which he/she can react. According to eGyankosh (2017), it is an intentionally planned experience in selected situations where students actively interact, participate and which result in achieving desired learning objectives. Therefore, Tyler (1949), categorized the learning experiences as follows:

- Learning experience that develops thinking skill.
- Learning experience that is helpful for acquiring information.
- Learning experience that is helpful for developing social attitude.

- Learning experience that is helpful for developing interest.

The third step is the organization of learning experiences for the purpose of achieving the desired curriculum objectives. Learning experiences should be organized in a way that the ideas and concepts are linked with the curriculum contents. Grouping and placement are the major factors in the organization learning experiences in the curriculum. For the grouping of learning experiences (contents and activities), the most extensively used method under subject headings is the traditional method. The placement of learning experiences includes the three major criteria which are continuity, sequence and integration. The last step of the Tyler's model is the evaluation of learning experiences. This last step determines the achievement of the curriculum objectives by the learners, hence evaluates the effectiveness of the selected learning experiences.

The Tyler's model was identified to have several advantages. According to Glatthorn et al (2015), it is the most understandable and easily applicable model. It mainly focuses on curriculum strengths and weaknesses, rather than on the performance of students as individuals. It also prioritizes the importance of a continuing cycle of analysis, assessment, and improvement (Glatthorn et al, 2015). Nonetheless, there are some disadvantages of this model, which other researchers are concerned about. According to Brummelen (1994), scientifically the model to some extent infers educators as being responsible for predetermining the desired outcomes of learners without fully considering the values, social constructs, needs and prior learning of participants. He considers that as narrow minded, given that teaching and learning are mutually dependent. Hence, the success of learners also depends on the level of their involvement and participation. Also, some scholars state that Tyler overlooked the role learners play in the ownership of their learning (Brummelen, 1994; Glatthorn, 1994). Others stated that the model does not recommend the necessary changes to the curriculum, it is identified as linear and performs no actual process of action research, modification or readjustment (Ibehi, 2021; Guba, 1981).

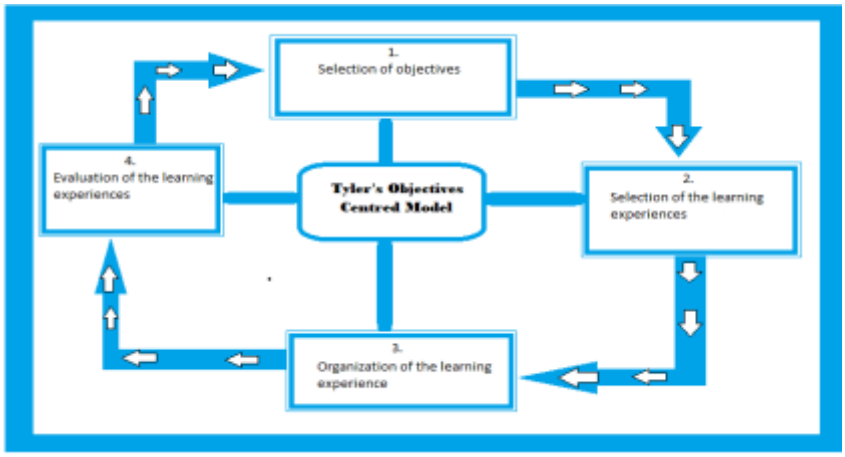

Figure 1: Illustration of Tyler's Objectives-Centered Mode

Regardless of the criticisms, the Tyler model continued to gain fame in curriculum development. Some curriculum specialists and teachers went to an extent of considering it as a standard procedure (Cruickshank, 2018). In his book, Tyler mentioned that he never intended to compile a manual for curriculum construction; rather he was providing an alternative method for teachers and students to use it personally for the effectiveness of their curriculum in their private spaces (Tyler, 1949). In that regard, the application of the Tyler model has been greatly utilized but without receiving a formal recognition in the publication space. Nevertheless, some scholars took it upon themselves to apply the Tyler's model in their work and gave proper due recognition. Fundi (2015) mainly focused on the evaluation part of the Tyler's Model. He evaluated the students of Dunwoody High School, using their biology and physical science end of course tests, and concluded that Dunwoody High School students attained the curriculum objectives of those courses. The current study is of the view that there is still a room for improvement in Fundi's work. Tyler in his model strongly recommends on taking at least two appraisals for proper evaluation, where the first appraisal must be prior to the commencement of the program and second appraisal after the end of the program (Tyler, 1949). In the work of Fundi (2015), the first appraisal prior to the commencement of the

program was never considered. Also, it is not recommended to use the school test, since under normal circumstances school tests do not cover all the curriculum objectives (Tyler, 1949). In that regard, they are not a suitable instrument to evaluate the attainment of curriculum objectives. In the work of Fundi (2015), school tests were used for the evaluation of curriculum objectives. However, the current work appreciates the good effort put in by the researchers in the application of Tyler's model.

2.2. Development of the Tyler Model Application Approach

Tyler developed a set of rules for the purpose of enhancing teaching and learning. His intention was for everyone to personally use the model; hence, he did not put many constrains to the application of the model. This means he allowed the model to be flexible and modifiable to best suit different situations. Therefore, in this section we are presenting a new application approach of the Tyler model. Where the main aim of the application is to evaluate the level of the curriculum objectives attainment by students, and to further evaluate the underlying factors if the objectives are not attained at a satisfactory level. The new approach consists of the following six steps.

Step 1

To start the evaluation process, one has to declare the selected curriculum objectives to be attained. The reason being, the objectives must be first known before being evaluated (Tyler, 1949). In this case, since the evaluator is dealing with an existing curriculum which already has objectives, declaration of the curriculum objectives will not be a challenge. In this step the evaluator gets an opportunity to make sense of the objective and determine if they are reasonable. Reasonable questions to ask are: i) Are the objectives at the same level as students? ii) Are the objectives aligned with the curriculum content? iii) Are the objectives relevant to the course of study? iv) Are the objectives achievable? These are the questions that are necessary to be asked in the beginning to avoid an unforeseen stray during the evaluation process. In that regard, if all the objectives are known and answers to the four questions are "yes", then the evaluator can proceed to step 2.

Step 2

After stating the objective(s), the evaluator should seek situation(s) (data collection instruments) which will present students with an opportunity to demonstrate the behavior implied by the declared objective(s) (Fundi, 2015; Tyler, 1949). That is when the evaluator will be able to observe the extent to which the objective(s) are being attained. There are two options for obtaining the data collection instrument(s). The first option is to search for an existing data collection instrument, that will involve examining them to see if they can serve the current evaluation purpose against the declared objective(s). It should be noted some data collection instruments are widely recommended but do not fit all evaluation purposes (Tyler, 1949). In that regard, the data collection instrument(s) should be examined by checking them against the declared objective(s). The second option is to construct a data collection instrument. Sometimes it is impossible to find a relevant data collection instrument that fits the current evaluation purpose. In that case, the evaluator should construct the data collection instrument(s) that would best fit the current evaluation purpose. The following is a guide for the data collection instrument(s) construction (Tyler, 1949):

- Firstly, the evaluator should identify the situation(s) that will present students with an opportunity to express the behavior inferred by the declared objective(s).
- Secondly, the evaluator must devise a plan of recording the desired students' behavior. Normally this is not a challenge in a case where the desired behavior can be assessed through a pencil and paper test. In such a case, participants make their own records when they write. However, in cases where students' reaction is assessed, the evaluator should formulate a method of obtaining recordings of the desired students' behavior.
- Thirdly, the terms or units that will be utilized for the categorization of the records of the obtained behavior must be decided upon. Given, the classification of the behavior differs according to the evaluators and objectives. For example, when we look at a particular student's problem-solving behavior; one can rate it as good in the perspective of creativity whereas the another could rate it as poor in the perspective of analysis. Therefore, categorization is necessary since some behaviors (like problem-solving) might not be properly evaluated if not categorized, given they might represent more than one objective (like creativity and analysis) if not categorized.
- Fourthly, the evaluator must make sure that the data collection instrument is objective. Presumably, if two different individuals display the same behavior, the data collection instrument should be able to score those two individuals either with the same scores or scores with an insignificant difference. The simplest ways to keep accuracy is to put specifications on the scorings.

- Lastly, the evaluator should validate the data collection instrument's reliability. The instrument should be investigated to check if it is within the capabilities of the participants.

Step 3

At this point, the curriculum objectives and data collection instrument are known. The crucial missing information is: how do we know if the curriculum objective(s) are attained satisfactory? Therefore, this step is about investigation of the curriculum objective(s)' attainment, concurrently the evaluation of the effectiveness of the elected learning experiences; since the selected learning experiences are the driving force behind curriculum objectives attainment. The new approach developed in this step, will be applied on the collected data to evaluate curriculum objectives attainment and effectiveness of the selected learning experiences. The evaluation assessments (data collection instruments) which were created by following step 2, are recommended to be at least two assessments (Tyler, 1949). However, the current study recommends only two assessments; which are pre- and post- assessments. The pre-assessment should be used to assess students on their first day of arrival, this is to evaluate the level of knowledge and skills students had before engaging the curriculum. Whereas the post-assessments should be used to assess students at the conclusion of the curriculum. The percentage score difference (x_i) between each student's pre- and post- assessment, determines the impact of the learning experience on each student. Hence the average difference ($\bar{X}$) determines the overall impact of the learning experience on students. The percentage difference (x_i) and average difference ($\bar{X}$) where the total number of students (N) is given, are mathematically expressed for n number of students as follows:

$$\left.\begin{aligned} x_i &= \left(\frac{b_i - a_i}{100 - a_i}\right) \times 100\,; \quad i \in \{1,2,3,\dots,n\},\ a_i \neq 100\ and\ x_i \geq 0. && (a) \\ and & \\ \bar{X} &= \frac{\sum_{i=1}^{i=n} x_i}{N}\,; \qquad N > 0 && (b) \end{aligned}\right\} \quad (2)$$

The percentage score difference (x_i) in (2) (a) is pioneered in the current study. On the right-hand side, it consists of the two parameters namely, the score of each student's pre-assessment (a_i) and post- assessment (b_i). The aim is to measure the score improvement of each student between pre- and post-assessment in percentage. Therefore, the student's score improvement is determined by the difference between post- and pre- assessment scores ($b_i - a_i$). In generally to determine a percentage you divide a part by a whole, then multiply everything by 100. In our case to express percentage score difference, we needed to express the whole, since the part ($b_i - a_i$) has been already obtained. Therefore, since each student starts by obtaining a_i score, then the room for improvement will be less-than or equal to 100; that is if 100 is the maximum score each student is trying to improve to. In that regard, the room for improvement (whole) will depend on a_i, hence the whole becomes ($100 - a_i$). In applying the explained approach of percentage calculation, the current study produced (2) (a). At the same time when applying the notion of averaging, it produced (2) (b).

The selected learning experiences are concluded by using the average score difference ($\bar{X}$) in the current study. The average score difference ($\bar{X}$) is categorized as follows:

Case 1: $\bar{X} \geq 50\%$

This case implies that curriculum objectives attainment improvement is at least 50%, which is an indication of a functional selected learning experiences.

Case 2: $\bar{X} < 50\%$

This case implies that curriculum objectives attainment improvement is less than 50%, which is an indication of a dysfunctional selected learning experiences.

It is the recommendation of the current study to chose 50% as a threshold. However, the evaluators are not obligated to chose the same threshold, it will depend on their conditions and circumstances. Also, for an evaluator who will adopt the evaluation approach of the current study, there will be no need to develop a new method in this step but rather they will simply apply the method already developed in this step.

Step 4

In step 3, if the evaluator obtains case 1 the evaluation process stops; that means the aim of the curriculum is being fulfilled. However, if case 2 is obtained the evaluation process continues; the aim of the curriculum is not fulfilled. Therefore, the next endeavor is to identify the reason for the learning experiences to be dysfunctional. If the learning experience in operation is unsuitable, it is unlikely that the curriculum objectives will be satisfactorily attained. Therefore, in this step the evaluator must seek to identify the type of learning experience that is operating and evaluate

if it is capable to produce the desired curriculum objectives. That will be achieved by using the idea of Tyler (1949), he categorized curriculum objectives into three categories and defined functional learning experience for each category as follows:

- Objective(s) focusing on thinking skills - This group of objectives comprises of creative, deductive, inductive, logical thinking and many more kinds of thinking skills. An appropriate learning experience for this case should use different problems, where students will not be able to immediately solve those problems by taking their solutions from their study materials. These problems should require students to relate various ideas and facts to produce required solutions. Also, this typical learning experience should require students to see and follow the steps of thinking in their normal sequence when they solve problems (Tyler, 1949).
- Objective(s) focusing on acquiring information - This category of objectives involves expanding knowledge about various things, developing understanding of things and the likes. Normally, the type of information to be acquired includes principles, theories, laws, facts, terms, ideas and many more. When information is acquired, commonly there are challenges such as: i) instead of acquiring the real understanding, students normally would just memorize; ii) students easily forget the acquired information and have inaccuracies in what they can remember and iii) students lack satisfactory organization, they would not relate the information in any organized or systematic manner. Therefore, the appropriate learning experiences for this category would be the ones that can meet the needs of the mentioned challenges and the likes. The first recommended learning experience is to let students acquire information through problem solving. This typical learning experience is less likely to make students memorize, but instead it produces understanding in them. Secondly, it's a learning experience that prioritizes only selected information worthy to be remembered. Instead of having countless technical terms in which part of them are worthier to the next level or class, rather the number of terms chosen should be minimal and frequently used for students to acquire information with accuracy. In addition, intensity and variety of expressions should be the priority. That combination is said to have higher chances of increasing remembrance. Thirdly recommended, is the type of learning experience that will provide different schemes of the information organization. This experience allows students to organize the same material in multiplies ways (Tyler, 1949).
- Objective(s) focusing on developing interests - This group of objective(s) enables students to derive interest from areas of experiences that develops interest. Therefore, the suitable learning experience should expose students to areas that are capable to develop interest and ignite satisfaction from their explorations (Tyler, 1949).

Therefore, the evaluator should create a data collection instrument by following step 2. However, this time around the attention should focus on teachers/lecturers mostly. Also, the questions in the data collection instrument should seek to find the type of learning experience that is being practiced.

Step 5

In step 4, if the evaluator found the learning experience(s) not aligned with the stipulated curriculum objectives, the evaluation process stops and alignment of learning experience with the curriculum objective(s) takes place. Then start again the evaluation from step 3, this is to test if the aligment problems is the only reason behind the unsatisfactory curriculum objectives attainment. If it is the only problem, the second time evaluation should find objectives attained satisfactorily.

On the other hand, if the learning experience(s) are found to be aligned and suitable for the stipulated curriculum objectives in step 4, then the evaluation should continue. That leads to the evaluation of the last part in Tyler's model, which is the organization of the learning experiences. According to Tyler (1949), suitable learning experiences can be dysfunctional if they are not well organized. Therefore, the current step should be about the evaluation of the organization of the suitable objectives found in step 4. Where the focus will be on the placement of the learning experiences, which should be achieved through evaluating the three major criteria which are continuity, sequence and integration. According to eGyankosh (2017), the functions of the three major criteria are:

- Continuity - entails the placement of learning experience for the purpose of helping students to relate efficiency as they progress with the curriculum.
- Sequence - involves the placement of learning experience for the purpose of maintaining gradual progress from simple to complex, concrete to abstract,

and normal to abnormal within the curriculum.

- Integration - involves the placement of learning experience for the purpose of maintaining harmony within the curriculum.

Step 5 is a separate study on its own, its details would not fit in this exploratory study. However, the authors of the current work do not prohibit other evaluators to employ their own methods for the evaluation of the three major criteria.

Step 6

If in step 5 the evaluator found that learning experiences are not well organized, the evaluation should stop and organization of the learning experiences should take place. Then the evaluation process should start again from step 3. On the other hand, if the learning experiences are found to well organized, then it means the problem is beyond the model.

A more simplified form of the evaluation approach adopted in the current study is presented in Figures 2 and 3. The presentation in Figure 2 is the simplest form of the above detailed evaluation from step 1 to step 6. Whereas, Figure 3 presents the overview of step 1 to step 6, which shows a modification done by the current study to the Tyler's model sequence. Normally, the order of the Tyler's model is selection of the objectives, selection of the learning experiences, organization of the learning experiences and evaluation of the learning experiences. The current study's evaluation process followed the same order except instead of the organization of the learning experiences it began with the evaluation of the learning experiences. That is the choice of the current study which does not affect the impact of the Tyler's model but rather it serves the purpose of the current study.

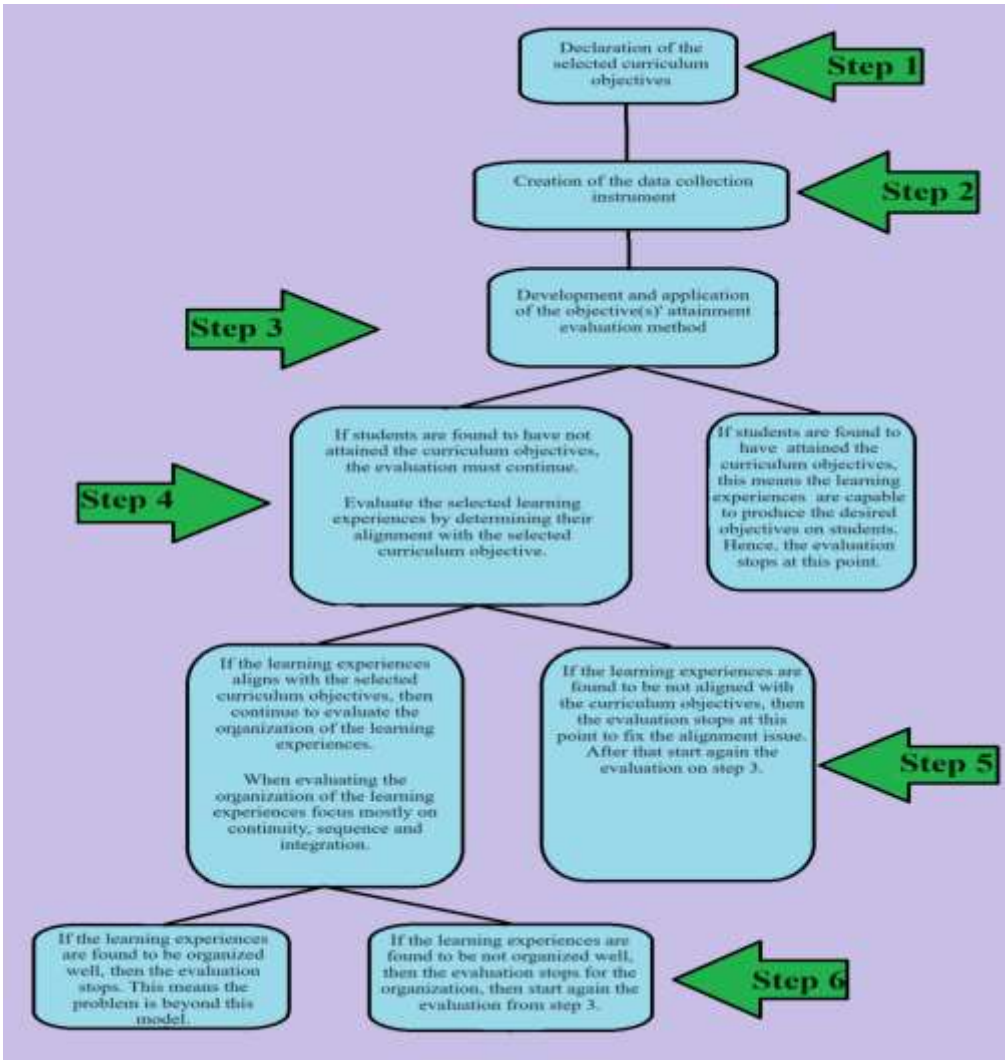

Figure 2: Application of the evaluation approach derived from Tyler's objective-centered model.

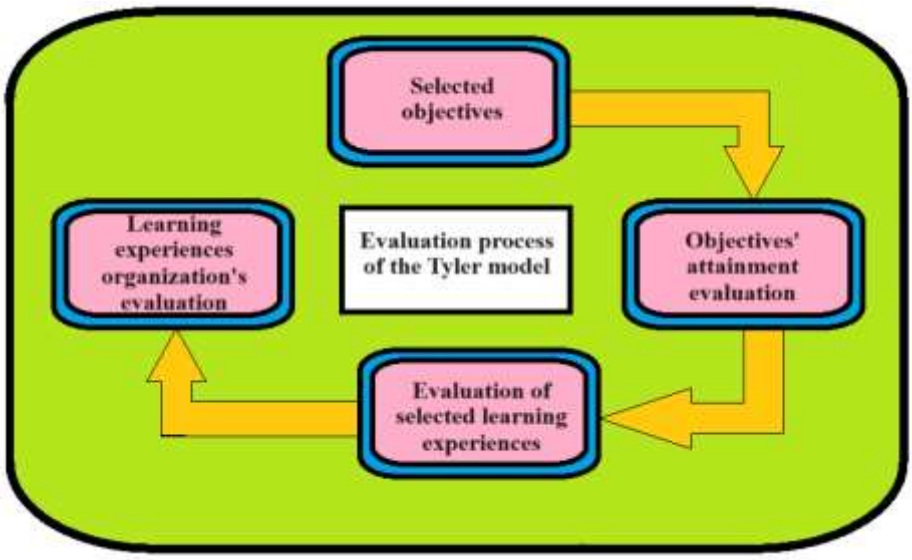

Figure 3: Overview of the evaluation approach adopted from Tyler objective model

3. RESULTS OF THE RESEARCH

The advantage of the evaluation approach developed in this study is that it is applicable to all curriculums that have objectives. In our case, we chose to evaluate N1 to N2 TVET (Technical Vocational Education and Training) colleges' mathematics curriculum in South Africa. After attaining N2 TVET training by the current South African government, students are allowed to undergo trade-test preparation and become artisans (Department of Higher Education and Training, 2015). To some extent this presumes that the N1 to N2 curriculum is sufficient to equip students for playing a significant role in the real-world space. Hence our interest is in N1 to N2 even though the National Accredited Technical Education Diploma (NATED) program goes beyond N2. Therefore, this section is about the application of the current study's evaluation approach to the N1 - N2 TVET colleges' mathematics curriculum. It is for the investigation of the extent to which the mathematics curriculum objectives are attained. The participants were forty-seven students from eMnambithi TVET college, KwaZulu-Natal province in South Africa.

Step 1 - Declaration of the selected curriculum objectives

The main objectives of the current investigated mathematics curriculum are to enable students to:

- apply mathematical principles.
- use the correct mathematical terminology and to identify the appropriate formulae.
- use the correct SI units
- reasoning logically

Step 2 - Creation of the data collection instrument

We could not find an existing data collection instrument suitable for our evaluation, in that regard we had to create new instruments based on our declared objectives.

- We identified situations that will provide students with an opportunity to express the four declared objectives; hence we constructed Appendices 1 and 2.
- In terms of recording the desired students' expressions, we did not have a challenge because as they express themselves concurrently they record their expressions.
- We constructed a scoring grid, Appendix 3, to facilitate the objectivity of our instrument.
- For validation, we compared the constructed questions in Appendix 1 and 2 with the students' curriculums. We were satisfied that their curriculum is sufficient for them to answer the questions successfully. Additionally, we used the last question in Appendix 2 to get the student's perspective. The results are presented in Table 1, which are responses of students to the question "is the data collection instrument relevant to their curriculum?" The results indicate that the first group (55.6%) responded yes, the second group (4.3%) responded no, and the last group (40.4%) did not respond to the question. The last group (40.4%) will not be considered since their perspectives are unclear. Therefore, we only considered the first and second groups. We found that the majority (93%) of the students considered the questions in Appendix 1 and 2 to be relevant to their curriculum. That supported our findings, that the curriculum might be sufficient for students to answer the questions successfully.

Step 3 - Evaluation of the curriculum objective(s) attainment

The average difference ($\bar{X}$) is used to evaluate curriculum objectives' attainment, and concurrently the learning experience as mentioned in step 3 of sub-section 2.2. Using the data collection instruments developed above in section 3, we produced Appendix 4 which indicates students' scores from pre- and post-assessments. All the necessary parameters required in calculating the average difference were extracted from Appendix 4, hence the average difference results are presented in Table 2. The average difference was found to be 15.34%, excluding student number 29 in Appendix 4. This particular student attained 100% for both assessments. In that case we are unable to measure improvement, since there is no room for improvement for that student. The calculated average difference is 15.34%, which is far less than 50%. This implies that, on average the learning experience(s) being practiced only improves the students' objectives attainment by 15.34% from the pre-assessment. Hence, based on our evaluation approach, we deduce that the current learning experience(s) in operation might not be effective enough to equip students for the curriculum objectives attainment.

Step 4 - Evaluation of the selected learning experiences

According to Tyler (1949) and eGyankosh (2017), the learning experiences depend on the following three components: selected learning situation(s), learning activities and students' interaction. Our data collection was challenged, we could not collect data for all the three components. Therefore, we directed our evaluation to the lecturers for the identification of the learning experiences they exposed their students to. A data collection instrument was formulated (Appendix 5) based on the first two components namely, learning situations and learning activities. The first two questions in Appendix 5 are about the selected learning situations and the other two are based on learning activities. Each question in Appendix 5 requires lecturers to choose options that are based on Tyler's model. Each of the options is based on a particular characteristic of a learning experience according to the Tyler model. The chosen option(s) by lecturers was compared with the Tyler model to conclude on the kind of the learning experiences that exposed their students to.

Table 1: Validation of the evaluation instrument with Appendix 3 question 10.

Group	Students' response	Number of students	Percentage	Percentage excluding group 3
1	Yes	26	55.6%	93%
2	No	2	4.3%	7%
3	No comment	19	40.4%	

Using Appendix 5, we assessed N1 and N2 mathematics lecturers separately and the results are displayed in Table 3. According to the N1 lecturer's response in Table 3, the learning experience being practiced in his/her N1 mathematics class is characterised with 50% of acquiring information and 50% of thinking skills. For N2, we could not extract the information about the learning experience in the two responses. However, the remaining two clearly showed that the dominant learning experience is the acquiring of information. In that regard, when combining N1 and N2, we result with the acquiring of information and thinking skills type of learning experiences. These were assumed by the lecturers to be suitable for a mathematics curriculum. However, our evaluation process will stop at this step because of the reasons discussed in the next section, the results discussion section.

Table 2: Parameters for learning experience evaluation extracted from Appendix 4.

Parameters	Actual Data Values
Summation of percentage difference	$\sum_{i=1}^{47} x_i = 705.44$
Total number of students	$N = 47$
Average difference	$\bar{X} = 15.34\%$

Table 3: Evaluation results from Appendix 5

N1 MATHEMATICS LECTURER		
Question [See Appendix 5]	**Response**	**Learning experience**
1) When you give examples, scenarios or explanations during your teaching sessions; which of the following is mostly your priority?	Using different schemes of information organization is my priority.	Focusing on acquiring information
2) If opportunities allow you, what kinds of equipment or instruments do you or would you mostly use for demonstration and explanation during your teaching sessions?	Equipment or instruments that will develop the student's thinking skills.	Focusing on thinking skills
3) What kinds of questions do you mostly ask your students during your class sessions or in a form of homework, tests, activities, and examinations?	I ask questions that require a student to use the acquired information.	Focusing on acquiring information
4) If you get a chance, what kinds of questions do you or would you influence your students to ask you during your teaching session or outside your teaching session?	Questions that cannot be immediately found in the textbook or any other publication.	Focusing on thinking skills
N2 MATHEMATICS LECTURER		
Question	**Response**	**Learning experience**
1) When you give examples, scenarios or explanations during your teaching sessions; which of the following is mostly your priority?	Using different schemes of information organization is my priority.	Focusing on acquiring information
2) If opportunities allow you, what kinds of equipment or instruments do you or would you mostly use for demonstration and explanation during your teaching sessions?	I'm not using or would not use any equipment or instruments for demonstration and explanation purposes.	No information extracted
3) What kinds of questions do you mostly ask your students during your class sessions or in a form of homework, tests, Activities, and examinations?	I ask unfamiliar questions that require a student to relate various facts and ideas.	Focusing on acquiring information
4) If you get a chance, what kinds of questions do you or would you influence your students to ask you during your teaching session or outside your teaching session?	Other kinds of questions not mentioned above.	No information extracted

4. RESULTS DISCUSSION

Our evaluation ended at step 4, where we identified that the learning experiences being practiced was an acquiring of information and thinking skills type of learning experiences. In our view, that type of a learning experience is supposed to be suitable for a mathematics curriculum that is being evaluated. However, it seemed to be not functioning, the attainment of the curriculum objectives was not satisfactory. Therefore, according to our evaluation approach,

we should have proceeded to step 5 which is the organization of the learning experiences. The challenge was that the evaluation of the three components was incomplete, the students' interaction was not evaluated. Hence, we don't know what would have been the final identified learning experience, since the student interaction was not considered. It is possible that the currently identified learning experience was unsuitable, given that not all components were considered for the evaluation. Therefore, our evaluation had to end at step 4 because of the insufficient data.

It should be noted that the current study is made-up of two parts, which are the development and application of the evaluation approach. The first part, the development of the evaluation approach was successful for an exploratory study. The second part, which is the application of the evaluation approach, was not completely successfully because of the insufficient data. We received an ethical clearance to collect data from nine TVET Colleges namely eLangeni, eThekwini, eMnambithi, eMgungundlovu, eMajuba, eMfolozi, eSayidi, Mthashane and Coastal TVET College in South Africa. We tried to contact their gate keepers but it was largely unsuccessful. Only the eMnambithi TVET college responded positively. We were able to collect some but not all the data we needed, for instance the student interaction data. Nevertheless, our study used and appreciated the data that was available. We knew that the incomplete data might not complete all the steps of the evaluation process. However, the evaluation steps that were covered would at least demonstrate to those interested evaluators how the evaluation approach application is done. The developed evaluation approach is likely to be good when the data is sufficient. Hence, this evaluation approach is available for adoption and improvement.

5. CONCLUSION

The average difference does not necessarily measure the actual quantity of the curriculum objectives attained, but rather it measures the improvement of student's objectives attainment from the pre-assessment to post-assessment. Similarly, a higher average difference does not necessarily reflect the high number of objectives attained, but rather it reflects a good impact of the learning experience on students. For instance, consider the cases of student A who obtained 2% on the pre-assessment and 60% on the post assessment, and student B obtained 90% on the pre-assessment and 90% on the post assessment. Student B would have a lower average difference (improvement) but higher objectives attainment than student A. Therefore, the introduction of the average difference in the developed evaluation approach is impactful, since it focuses on the effectiveness of the learning experience(s) instead of the quantity of curriculum objectives attained. When we observe the whole evaluation approach, it has advantages and disadvantages. The advantages are: i) the approach is applicable to all curriculum with objectives, ii) it has an allowance for evaluators to innovate new methods along the six steps for the approach to best suit their particular situation, and iii) it is easy to apply the approach. On the other hand, the disadvantages are: i) it might not work when the data is insufficient, and ii) to some evaluators that are not willing to be creative in step 5, the approach might be suitable for them after the future study that will provide details for step 5. In the future study the two disadvantages will be prioritized, for the efficiency of the evaluation approach.

6. APPRECIATION

We would like to convey our appreciation to eMnambithi TVET College for granting us the permission to collect data for the previous study. A special thanks to Ms. Beatrice Mpangase (in the principal's office), Mr. Phelelani Buthezi (campus manager), and all the Ezakheni E-section campus staff for their support throughout the period of data collection.

7. ETHICAL STATEMENT

The current study is part of a previous study titled "Investigation of the South African public TVET college's engineering official mathematics curriculum for entry level artisans". University of KwaZulu-Natal Research Ethics Office approved the previous study; hence the approval is still relevant to the current study since it is using the same data (Approval letter is available). In addition, we confirm that all processes were executed in accordance with all applicable rules and guidelines for data collection.

8. DATA AVAILABILITY STATEMENT

All the utilized data to accomplish the current study is available in this manuscript as Appendix 4.

9. INFORMED CONSENT

All authors confirm that we obtained approval from the UKZN Research Ethics Office Westville Campus to collect data. We collected data from young adults' students at eMnambithi TVET college in South Africa, KwaZulu-Natal, Pinetown. The informed consent was obtained verbally from the participants and the gate keepers of eMnambithi TVET college. The consent

was based on hiding the information of the participants.

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APPENDIX 1: Evaluation of Objectives (pre- assessments)

Application of mathematical principles mastered

1. The mass of a red car plus the mass of a black car is 900kg. Also, three times the weight of the red car plus the weight of the black car is 2300kg. What is the weight of the red car and the black car?

Use of the correct mathematical terminology and to identify the appropriate formulae

2. Fill in the missing words by choosing the correct combination bellow.
   The value $\frac{2}{3}$ can be also called a …… (i)…….. of the value $\frac{3}{2}$. The SI unit for the velocity (m/s) is derived from the formula …… (ii)……..

   a) (i) Fraction and (ii) $\frac{distance}{time}$
   b) (i) Denominator and (ii) $\frac{kilogram}{time}$
   c) (i) Reciprocal and (ii) $\frac{displacement}{time}$

d) (i) Exponent and (ii) $\frac{accelaration}{time}$

Use of the correct SI units

3. Identify the S.I unit for mass in the following:

a) Meters per second (m/s)
b) Meters (m)
c) Kilograms (kg)
d) Meters per second square (m/s^2)

Logical reasoning

4. If you work for one day you get paid R4, if you work for two days you get paid R7 and if you work for three days you get R10. What would you be paid when you work for 5 days?

Choose the correct answer from the following:

a) R9
b) R13
c) R16
d) R8

APPENDIX 2: Evaluation of Objectives (post assessments)

Application of mathematical principles mastered

1. The mass of a red car plus the mass of a black car is 600kg. Also, three times the weight of the red car plus the weight of the black car is 1400kg. What is the weight of each red car and each black car?

Use of the correct mathematical terminology and to identify the appropriate formulae

2. Fill in the missing words by choosing the correct combination bellow.

The value $\frac{10}{3}$ can be also called a …… (i)…….. of the value $\frac{3}{10}$. The SI unit for the velocity (m/s) is derived from the formula …… (ii)……..

e) (i) Fraction and (ii) $\frac{distance}{time}$
f) (i) Denominator and (ii) $\frac{kilogram}{time}$
g) (i) Reciprocal and (ii) $\frac{displacement}{time}$
h) (i) Exponent and (ii) $\frac{accelaration}{time}$

Use of the correct SI units

3. Identify the S.I unit for distance in the following:

e) Meters per second (m/s)
f) Meters (m)
g) Kilograms (kg)
h) Meters per second square (m/s^2)

Logical reasoning

4. If you work for one day you get paid R2, if you work for two days you get paid R5 and if you work for three days you get R8. What would you be paid when you work for 5 days?

Choose the correct answer from the following:

e) R9
f) R11
g) R14
h) R10

Evaluation instrument validation

Do you think all the questions from the first and second test are familiar or relevant to what you have learnt from the N1 to N2 curriculum and in class lessons?

(a) YES
(b) NO

APPENDIX 3: Marks scoring grid

PART 1 (OBJECTIVES OF THE SYLLABUS)	
Questions	**Marks Allocation**
Question 1: Application of mathematical principles mastered.	• Formulation of the first equation. [1 mark] • Formulation of the second equation. [1 mark] • Solving for variable 1 (red car mass/ black car mass). [1 mark] • Solving for variable 2 (black car mass/ red car mass). [1 mark] **Total [4 marks]**
Question 2: Use of the correct mathematical terminology and to identify the appropriate formulae.	• Knowing the first correct term. $\left[\frac{1}{2}\ mark\right]$ • Knowing the second correct term. $\left[\frac{1}{2}\ mark\right]$ **Total [1 mark]**
Question 3: Use of the correct SI units.	• Knowing the correct IS unit. $[1\ mark]$ **Total [1 mark]**
Question 4: Logical reasoning.	• Correct answer. [1 mark] **Total [1 mark]**

APPENDIX 4: Pre- and Post-assessment student's scores for curriculum objectives and HOTS

*Any negative percentage difference is set to be zero ($-x_i = 0$)

Student Order (i)	Pre-assessment scores (a_i)	Post-assessment scores (b_i)	Percentage difference (x_i)
1	0	29	29
2	29	0	0
3	29	0	0
4	14	100	100

5	0	43	43
6	29	0	0
7	14	29	17,44186
8	29	0	0
9	29	0	0
10	29	0	0
11	29	0	0
12	29	0	0
13	14	0	0
14	0	29	29
15	14	0	0
16	29	43	19,71831
17	0	14	0
18	29	29	0
19	29	0	0
20	14	14	0
21	14	14	0
22	14	0	0
23	0	14	14
24	14	14	0
25	29	14	0
26	29	29	0
27	71	29	0
28	29	29	0
29	100	100	0
30	86	100	100
31	29	14	0
32	29	86	80,28169
33	29	0	0
34	57	0	0
35	29	0	0
36	29	29	0
37	86	0	0
38	29	0	0
39	0	29	29
40	0	29	29
41	0	29	29
42	0	29	29
43	0	43	43
44	0	29	29
45	0	14	14
46	0	57	57
47	0	14	14

APPENDIX 5: Pre-evaluation questionnaires.

As a lecturer:

1) When you give examples, scenarios or explanations during your teaching sessions; which of the following is mostly your priority?

a) Using unfamiliar problems is my priority.
b) Intensity and variety of expression is my priority.
c) Using less technical terms as possible is my priority.
d) Using different schemes of information organization is my priority.
e) Using what interest them is my priority.
f) None of the above.

2) If opportunities allow you, what kinds of equipment or instruments do you or would you mostly use for demonstration and explanation during your teaching sessions?

a) I'm not using or would not use any equipment or instruments for demonstration and explanation purposes.
b) Equipment or instruments that will develop the student's thinking skills.
c) Equipment or instruments that will increase students' information or knowledge.
d) Equipment or instruments that will develop the student's interest.
e) I do or would use other equipment or instruments not mentioned above.

3) What kinds of questions do you mostly ask your students during your class sessions or in a form of homework, tests, Activities, and examinations?

a) I ask unfamiliar questions that require a student to relate various facts and ideas.
b) I ask questions that require a student to use the acquired information.
c) I ask questions that require student's interest.
d) I ask other kinds of questions not mentioned above.

4) If you get a chance, what kinds of questions do you or would you influence your students to ask you during your teaching session or outside you teaching session?

a) Unfamiliar questions.
b) Questions that cannot be immediately found in the textbook or any other publication.
c) Question that are in line with your interest.
d) Other kinds of questions not mentioned above.