TEACHERS' APPLICATION OF BLOOM'S TAXONOMY IN THE TEACHING AND ASSESSMENT OF CRITICAL THINKING SKILLS IN NIGERIA

Usman Muhammad[1*], Rabiatul Adawiah Ahmad Rashid[2]

[1] Universiti Sains Malaysia, Pulau Pinang
Email: usmanmz@student.usm.my; Tel: +601156672296
[2] Universiti Sains Malaysia, Pulau Pinang
Email: r_adawiah@usm.my
* Corresponding Author

Abstract:

This study focused on how teachers in Nigeria handle classroom instruction using Bloom's taxonomy and how its application promotes the teaching and assessment of critical thinking. It explored common instructional practices employed in the teaching and how it relates to either the lower or higher stages of Bloom's Taxonomy. It is believed that critical thinking and other high order thinking skills could only be promoted at the higher stages of Bloom's taxonomy. It explored how appropriate are the ways in which teachers' instructions addressed objectives related to critical thinking in their teaching and assessment process. In-depth interviews were used as the main instrument of data collection while thematic analysis method was used in data analysis. Five basic science teachers from some selected schools in Nigeria participated in the study. The study revealed that teachers uphold indifferent views on critical thinking skills, probably resulting from the inadequate preservice and in service training on the appropriate application of Bloom's taxonomy and how it could be employed to promote critical thinking in the teaching and assessment process. It showed that most teachers had limited knowledge and skills on how to handle the teaching and assessment of critical thinking skills.

Keywords:

Bloom's Taxonomy; Critical Thinking; Teaching and Assessment

Introduction

When critical thinking is related to Bloom's taxonomy's cognitive domains, teachers may have a better knowledge of it because it has been demonstrated to be a useful and significant tool

(Paul, 1990). According to Brown (2004), Bloom's taxonomy is an important framework for fostering critical thinking since it instructs students to "establish clarity and accuracy, evaluate relevance, and exhibit the ability to analyse in depth" (p. 76). Teachers can use Bloom's taxonomy as a tool for crafting learning objectives, designing lesson plans, evaluating students, planning class activities, and creating tests and exams in order to evaluate students' critical thinking (Anderson, et al 2001). Bloom's taxonomy is a hierarchical model of knowledge creation and thought that is "convenient, swift, efficient, testable, measurable, and responsible." Berry (2004), page 464. "(a) knowledge, (b) comprehension, and (c) application are lower-order thinking abilities; (d) analysis, (e) synthesis, and (f) evaluation are higher-order thinking or critical thinking skills" (Bloom, 1984, p. 18). In terms of the development of critical thinking abilities, the levels move from simple to complicated. Bloom's taxonomy's higher order skills, which include the processes to critical thinking, can only be obtained by satisfying the prerequisites for the lower-level abilities (Brown, 2004). However, the appropriate application of the taxonomy tends to be difficult for some classroom teachers particularly at the elementary school level in some developing economies like Nigeria.

There is a concern raised in the teachers understanding and preparedness in embracing the current and conventional methods of teaching for critical thinking (Aboluwodi, 2016; Ezechi & Ogbu 2017; and Ogunode et al, 2021). There also exists a gap on how critical thinking skills could be best assessed by the classroom teachers being the term critical thinking both cognitive & attitudinal concept leading to lack of adequate literatures on that and consequently poor understanding of teachers on how to assess their learners critical thinking skills (Jonassen, 2010; Olatunji, 2017).

Literature Review
The definition of critical thinking is not universally accepted. Despite the growing recognition of the importance of critical thinking in fostering national and individual development, there is still a lack of consensus regarding the definition of critical thinking. This can be attributed to the varying perspectives from which disciplines such as philosophy and psychology view it (Ab Kadir, 2007). For example, while philosophers emphasise critical thinking, the nature and quality of the products of critical thinking, and focus more on - for instance, the analysis of arguments, psychologists emphasise the concept of thinking skills process of cognition, the components and operations used to address academic and practical issues.

Philosophers' Perspective
Philosophers have varying conceptions of what critical thinking entails, but they all place a strong emphasis on the value of argument analysis, which stems from informal logic, as well as the necessity of focusing on the analysis of arguments based on their soundness and validity and the vital role of thinking dispositions (Paul, 1993). Critical thinking teaches us how to analyse and increase our capacity for sound judgement, which prepares us to enter practically any situation and grasp its logic. Through a process of continuous self-evaluation, this enables us to learn from new experiences, as critical thinking enables us to construct sensible thoughts and judgments, which in turn enables us to make better decisions and offers us the foundation for a rational and reasonable existence (Olatunji. 2017).

Psychologists' Perspective

In contrast to theories based in philosophy, theories of critical thinking based in psychology are focused with cognitive processes (Olatunji, 2017). Moreover, he asserts that although psychologists emphasise critical thinking skills, philosophers emphasise critical thinking dispositions, which are the attitude, mental habits, or internal motivations that enable an individual to use critical thinking skills (seeking facts, seeking the truth, curiosity, scepticism, cognitive maturity, self-confidence, willingness to entertain the views of others, fair-mindedness, open-mindedness desire to be well-informed, etc.). The definitions of critical thinking reflect this distinction that psychologists have emphasised (Olatunji, 2017). According to Kurfiss (1988, p. 2), critical thinking is an investigation that seeks to investigate a scenario, phenomena, topic, or problem in order to arrive at a hypothesis or conclusion that takes into account all available evidence and may, thus, be convincingly justified. This is an example of a psychological definition of critical thinking. Similar to this, Shakirova (2007) says that critical thinking skills are essential because they enable students to successfully resolve social, scientific, and practical problems.

Distinct Areas of Agreement

According to Facione in Olatunji (2017), the Philosophy Association of America commissioned a research project to establish an agreement on the topic of critical thinking's definition. According to the report, critical thinking is defined as purposeful, self-regulatory judgement that leads to interpretation, analysis, evaluation, and inference, as well as an explanation of the evidential, conceptual, methodological, criteri-ontological, or contextual considerations upon which the judgement is based (Facione in Olatunji, 2017).

Bloom's Taxonomy and Critical Thinking

Contemporary theories such as cognitive information processing and Bloom's Taxonomy have supported the teaching and evaluation of critical thinking as a cognitive talent (Bloom, 1984). Modern Cognitive Information Processing theory is important in assisting educators to comprehend how students engage with information; accordingly, its use may equip teachers to assist students in decoding, retrieving, and making sense of new data. This hypothesis of cognitive Information Processing merits investigation since it is largely associated with memory, which is a prerequisite for more sophisticated cognitive activities such as comprehension, analysis, and synthesis.

The term "critical" in critical thinking refers to two distinct concepts: It first proposes that the human mind possesses a default, non-critical thinking state. In this non-critical state, the mind becomes a repository for information and a conduit for unfiltered thoughts and arguments. The accepted as normal becomes the standard. In contrast, when in a critical condition, the mind engages sophisticated cognitive systems to filter information and evaluate conclusions. The assumption is challenged and problematized. This comparison between critical versus uncritical thinking is based on a general discussion of taxonomies for thinking skills.

Bloom's taxonomy, which was developed in 1956, is one of the most well-known taxonomies that attempts to divide educational objectives into various thinking skills organised across a continuum of cognitive complexity with higher order thinking skills at one extreme and lower order thinking skills at the other. Anderson, et al, added the following six verbs to Bloom's taxonomy in 2001: recall, understand, apply, analyse, evaluate, and create. As reported by

Newton et al. (2020) Most students concentrate their efforts on the first three components of cognitive complexity. Analysis, evaluation, and production are the three higher-order cognitive complexity domains necessary for critical thinking and creativity, they further asserted.

Critical thinking and Bloom's Taxonomy go hand in hand. Teachers can guide students through the cognitive process of analysing critical information or knowledge by employing Bloom's taxonomy. Bloom's taxonomy begins with knowledge and memory and eventually encourages students to seek out more information through a sequence of questions and keywords that prompt learners to act. Bloom's taxonomy and critical thinking are both required for metacognition and education.

According to Baddeley (2007), the assumption that retaining information in the short-term memory is sufficient for the information to be transmitted to the long-term memory is inconclusive, as is the assumption that preserving information for a longer period of time or increasing the probability of transfer leads to enhanced learning. Moreover, he contends that the depth and richness of how the material was encoded is a stronger predictor of learning than the length of time the material was held in the short-term memory (Baddeley, 2007). This suggests that instruction that incorporates techniques for manipulating existing information, such as using it to create a new product or verify a hypothesis, may be more effective at promoting meaningful learning than instruction that emphasises rote learning, repetition, recall, and other short term memory retrieval strategies. The application of information to identify solutions to problems and apply it in a new context is an important characteristic of critical thinking that should be a learning outcome of every teaching episode, whereas iconic representations and recall of basic information from short-term memory are less significant.

Even with a young adult, formal operational thought may not be fully developed. Consequently, the cognitive readiness of pupils for activities requiring abstract and deductive reasoning is an additional aspect that may be evaluated (Cotter & Tally, 2009). This is because efforts to foster critical thinking may fail in the absence of cognitive apparatus. Since most children are naturally curious, early exposure to learning and the environment should prepare them to explore, question, and solve problems in informal learning situations. Bloom's taxonomy of the cognitive domain is a framework that is employed across all levels and disciplines to immerse students in discovery-based learning environments and better prepare them for college-level critical thinking. Regarding mental processes, the implementation of this taxonomy enables students to use a combination of lower and higher order thinking skills and helps teachers build their questioning method for instructional and evaluative tasks (Bucy, 2006). According to Parker (2009) and Ogunode et al, (2021), research reveal that a significant number of teachers often ask pupils to only learn and recall factual knowledge. Further, he argues that although recall of facts is a prerequisite for more sophisticated cognitive functions, critical and analytic thinking is cultivated when students are pushed to interpret, evaluate, and synthesise information often. Fundamental skill memorization and acquisition are essential to critical thinking activities. Therefore, "the more adept you are at lower-order abilities, the more adept you can become at higher-order skills" (Lemov, 2010, p.19).

Critical thinking is frequently characterised as the process of classifying and examining one's own thoughts. According to Bissell and Lemons (2006), Bloom's taxonomy is the best technique to classify critical thinking in the classroom. This classification can be used to examine critical thinking using the six levels of cognitive thought. Students are able to navigate

the taxonomy from lowest to highest level. Paul (1993) found that higher-order thinking skills are typically encountered during the synthesis, evaluation, and design stages, despite the fact that critical thinking is present at all levels. This is also consistent with Mike's (2018) and Newton's et al, (2020) assertions that critical thinking as a higher-order thinking skill occurs exclusively at the top/last three levels of the taxonomy.
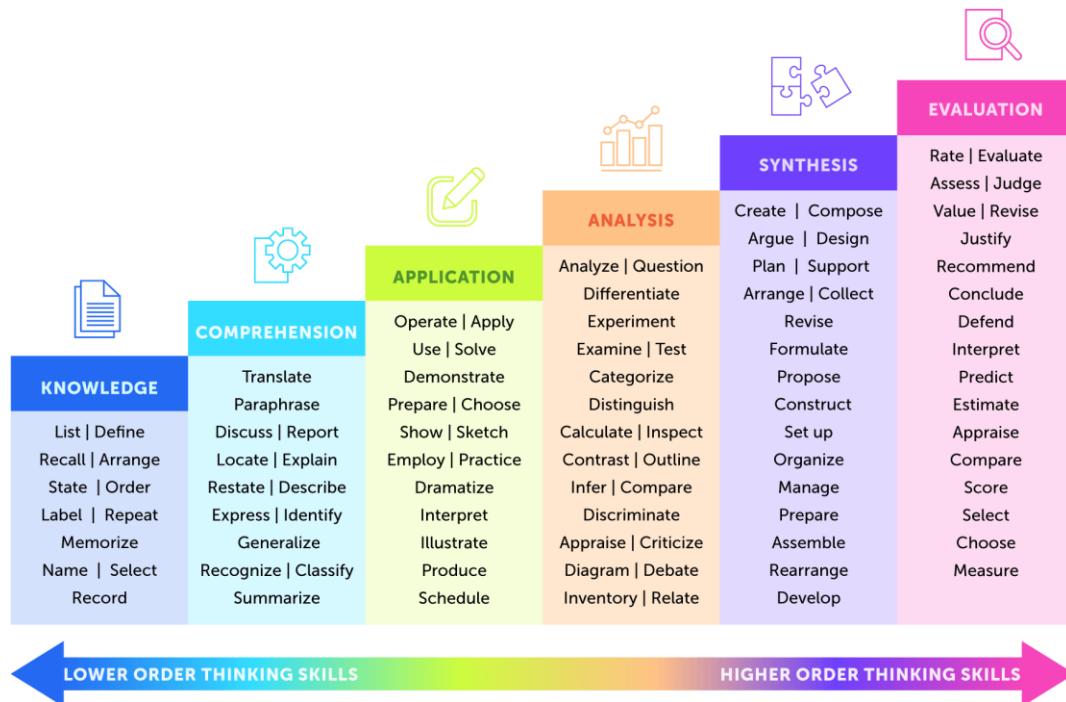

Figure 1: Lower Order and Higher Order Thinking Skills Levels of Bloom's Taxonomy

Constraints For Teaching Critical Thinking in Nigeria
One of the major constraints for promoting critical thinking in Nigeria is the teaching and learning of traditional type. Tradition is an authority that may impede intellectual progress. The traditional methods of teaching and learning in Nigeria could also be attacked, since they impede the promotion of critical thinking in the teaching-learning process in two ways, namely through the curriculum and the teaching technique (Olatunji, 2017; Kalusi, 2017).

In Nigeria, it is difficult to teach critical thinking through "formal" instruction with formal materials and overstated learning outcomes (Enoh, 2013). The topics and their textbooks/learning contents are governed by the Ministry of Education, and their contents serve as political, economic, and cultural tools. In addition, the objective of teaching and learning is limited to preparation for admission examinations, with an overemphasis on the cognitive domain of the learner at the expense of other learning domains. Thus, "memory" becomes the most essential skill taught and acquired in school (Ogunode et al, 2021). This type of bookish education, which was initially criticised after Nigeria's independence as a remnant of colonial education, assumes that the success of learning must be measured by the amount of information that children can reproduce or repeat from what they have learned in class, as evidenced by their ability to reproduce what they may have memorised.

On a second note, conventional authority is manifest in the pattern of instruction and classroom structure (Kalusi, 2017). It would be difficult to obtain enlightenment of reason by conventional

methods of teaching and learning, which are typically employed to accommodate the vast quantity of content to be taught (Olatunji, 2017). The brains of learners cannot be enlightened simply by pushing learning materials on them. Rather, it is necessary to encourage their scepticism by cultivating their self-reflection skills and promoting their individuality. Other impediments to the teaching of critical thinking may include the inadequacy and inappropriateness of the teacher education obtained by teachers and its consequences on pupils, as well as the creation of scientific education curriculum.

Method

Research Design
This study employs a descriptive qualitative case study research method of inquiry. Thus, it is designed in a qualitative mode. Qualitative research mode is required in this study to investigate the facts about the appropriate application of Bloom's taxonomy (higher order stages) for promotion of critical thinking skills in the teaching of basic science education subject to the students at upper basic school education level in Nigeria with reference to the classroom teaching and learning instruction. A descriptive case study was chosen as the research methodology because it is open-ended and enables a thorough understanding of the topic being examined, (Creswell, 2014; Merriam, 2009). Understanding a complex subject is the final objective of qualitative research, which can also broaden experiences or reinforce existing knowledge. This descriptive case study helped researchers better understand how teachers encourage critical thinking abilities in practical classroom settings, from their own contexts and viewpoints (Creswell, 2014; Yin, 2013).

Study Location
The topic is limited to the basic science education level in Nigeria, hence the research sites only limited to the schools under Universal Basic Education level under the Federal and State levels: Five upper Basic Education Schools (specifically Upper basic levels 1-3). At least one participant selected from each school based on the stated criteria under the purposive sampling technique. To be gender sensitive there were two schools from boys schools, two girls schools and one mixed school for boys and girls. The schools (research sites) were selected from: a. Federal Government (Science) colleges; b. State Unity School and c. State Government Secondary School. Thus, the schools (research sites) visited, were: Federal Science College Sokoto and Federal Government College Sokoto (under a) category); Sani Dingyadi Unity Secondary School Sokoto (under b) category); Nana Girls Secondary School Sokoto and Government Girls Secondary School Sokoto (under c) category), respectively. See table 1 under participants of the study, below.

Study Population

Reference Population
The study is a descriptive qualitative case study set in Nigeria, and it is hoped that the general findings will be applicable in all basic science schools in the country. Thus, the population of the study comprises all basic science teachers in the public upper basic schools in Nigeria.

Target Population
Particularly, the target population are upper basic science education teachers in Nigeria.

Source Population / Sampling Pool

The sample of participants were drawn from the list of basic science teachers in the schools serving as research sites.

Subject Criteria

The sampling is purposive in nature because it is a descriptive qualitative case study research to ensure correct type of respondents are interviewed on the basis of their area of specialisation, (i.e Basic Science Education subject) teaching in upper basic 1-3 (i.e. JSS 1-3) so that the sample reflects the entire population of the study. Thus, to reduce the degree of bias, the researchers selecting the participants on the bases of their teaching subject, teaching classes, qualification, employment status, and years of experience of the participants, in the above hierarchy respectively, which is also very purposive in nature (using purposive sampling technique). This is because they are expected to have high level of expertise in the teaching instruction.

Sample Size Estimation

This qualitative sample size was chosen because Creswell (2014) suggests that 5-25 people should be chosen for phenomenological research which is interviewing samples for their experience and views. The lowest sample size for saturation was 5 interviews (Constantinou et al., 2017), in a study with a homogenous study population that was intended to support survey findings and where saturation was sought in broad categories. The sample size of five (5) participants in this study is therefore justified by the homogeneity of the population (who are purely basic science teachers with the same type of teacher training, operating under the same educational system, guided by the same curriculum, working conditions, etc).

Table 1   Purposive Sampling Criteria

S/N Criteria	Inclusion Criteria	Exclusion Criteria	Withdrawal
1.	Teachers of Basic Science	Teachers of other subjects	Sickness
2.	Teachers of Upper Classes	Teachers of Lower classes	Noninterest
3.	Teaching Qualification	Non-Teaching Qualification	Engagements
4.	Permanently Employed	Non permanently employed	Long Travel
5.	Teaching Experience	Newly Recruited Teachers	Abscondment

Source Author, 2024

Research Instrument

Instrument used in collecting data for this study is primarily interview protocol. The interview protocol used involve several different question formats, which are semi – structured and subjective in nature. Semi-structured interview, according to Adedoyin, (2020), is a data collection approach that the interviewer is not obligated to adhere to exact formal questions. The interviewer is expected to ask open-ended questions while giving room for conversation with the respondents (i.e. interviewees) instead of direct question and response structure.

Data Analysis

The method of data analysis used in this study is a thematic analysis of themes extracted from the interview transcript. Braun and Clarke's framework for theme analyses was utilised. The interview transcript was analysed using the Braun and Clerk's Thematic Analysis.

Findings

From the questions on the application of Blooms' taxonomy for the teaching and assessment critical thinking skill, the researcher then investigated how the teachers include the elements of critical thinking in their lesson plan in teaching basic science education. The themes generated under this research question are therefore highlighted as follows: There are no stated objectives on critical thinking; teachers emphasise lower order behavioural objectives; some teachers employ non behavioural objectives; critical thinking at basic science level is recommended with strong concern on the students' maturity and ability for the thinking. The themes therefore revealed that the teachers mainly include terms that are within the lower order components of behavioural objectives from Bloom's taxonomy (that is the terms that measure the components of students' Knowledge, Comprehension and knowledge Application). Therefore, teachers' emphasis was on the statement of behavioral objectives in their basic science classroom lesson not on any thinking skill. Some of the teachers' responses also reveal their statement of non behavioural objectives. From the findings of the study thus, the teachers do not state any lesson objective that promotes the elements of critical thinking in their classroom teaching.

The findings on how the teachers inculcate element of critical thinking in their methods of instruction in teaching basic science education, reveal the following themes: Non critical thinking pedagogy; teacher centred classes; non critical thinking learning environment; difficult learning contents; inadequate resources; and non-critical thinking training (preservice and in-service teacher training). Therefore, there were employment of teaching methods and instructions of traditional type. Teachers interviewed expressed that they employ classroom discussion as their preferred method of instruction because they believe it is most suitable for students to easily remember, recall and comprehend the contents of the lesson. It is found that the teachers are employing traditional methods of instruction. The classroom questioning is basically on behavioural objectives. Teachers interviewed lacked knowledge on teaching and learning theories of critical thinking pedagogy. The classroom questioning strategies are of non behavioural type. Teachers are employing non-thinking provoking questioning. Teachers interviewed express their weaknesses and difficulty in teaching some basic science contents which are not within their area of specialization. The teachers didn't receive any adequate training either as preservice or in-service training on the critical thinking pedagogy and theories of critical thinking learning. They also expressed high difficulty of some learning contents which they associated with their weakness with some components of basic science subject outside their area of specialization and also due to the students' poor academic background. The language of communication problem stands as one of the major constraints in the teaching of basic science education because the students couldn't understand the scientific terminologies used in the class while the teachers could not also find their words equivalents in the students' mother tongues. Teachers interviewed also acknowledge the importance of using the classroom demonstration methods using diagrams but due to inadequacy of instructional and infrastructural facilities, teachers are limited from adequately employing the method because they will have to improvise from their limited resources.

Research findings on how the teachers include the elements of critical thinking in their methods of assessment process in teaching basic science education, reveal the following themes: Non assessment of critical thinking; Assessment on behavioural objectives; Assessment of non behavioural objectives; in appropriate questioning strategies and; the assessment was guided by curriculum provisions. From the identified themes therefore, there wasn't any effort for the assessment of the elements of critical thinking. The frequent assessment questions simply measure students' knowledge of the learning contents as evidenced in their ability to remember, recall and reproduce the information. These are the lower order behavioural objectives. From the first components of Bloom's taxonomy (measuring **knowledge**), where teachers ask students to mention, state, define etc. The second order assessment questions of the teachers measure the students' **comprehension** of the learning contents, which constitutes the level two components of the taxonomy, using terms like classify, differentiate and identify, etc. The last the third component were the teachers assess the students' knowledge **application,** which is the third level or components of Bloom's taxonomy, was rarely assessed. This is because teachers' assessment is strictly guided by curriculum provisions which doesn't value critical thinking efforts.

Discussion
The results from the conducted interview, indicate that the teachers primarily employ terms from levels one and two of Bloom's taxonomy. The terms used by the teachers are limited to level three Bloom's taxonomy components at most. Therefore, the terminology often employed by instructors in the statement of behavioural objectives for their elementary science lesson fall under the lower order levels of thinking. Some of the terms employed by the teachers in their lesson objectives reflect the application of non-behavioral terms. According to the findings of the study, teachers did not include assignments requiring higher order thinking skills in their lesson objectives that foster elements of critical thinking.

Critical thinking is frequently defined as the classification-based analysis of one's own thoughts. According to Bissell and Lemons (2006), Bloom's taxonomy is the best technique to classify critical thinking in the classroom. This classification can be used to examine critical thinking using the six levels of cognitive thought. Students are able to navigate the taxonomy from lowest to highest level. Newton et al, (2020) found that higher-order thinking skills are typically encountered during the synthesis, evaluation, and design stages, despite the fact that critical thinking is present at all levels. This is also consistent with Mike's (2018) assertion that critical thinking as a higher-order thinking skill occurs exclusively at the last three levels of Bloom's taxonomy. Unfortunately, none of the terms commonly used by basic science teachers in their lesson objectives correspond to the upper/last three levels of Bloom's taxonomy, which, according to Newton et al, (2020) and Mike (2018), are the only levels where critical thinking as a higher-order thinking skill occurs.

Teachers employ non-thought-provoking inquiry. The classroom questions mostly addressed behavioural objectives. Some classroom inquiry techniques are not based on behaviour. The characteristics that cannot be quantified or evaluated. Teachers interviewed frequently use phrases such as "do you understand?" Do you understand? Are you keeping up? Etc. Even in traditional schools where the use of behavioural concepts is expected, these types of questions are discouraged. Therefore, they appeared less suitable for the thinking skill-centered classroom lessons. Instead, teachers are supposed to pose thought-provoking questions. Good and effective questions are those that inspire students to interpret, evaluate, synthesise, critique,

and reflect. This is one of the most powerful tactics that teachers may use to foster critical thinking. Questions that can prompt students to question the veracity or validity of any unsubstantiated claim or perspective. According to Ikuenobe et al. (2001) and Shaunessy et al. (2005), this form of questioning has been accepted by educators as an open-ended process of inquiry and a function of critical thinking that teachers should cultivate in their pupils.

The frequently used evaluation questions simply assess students' knowledge of the course material, as demonstrated by their abilities to remember, recall, and reproduce information. These are the level one (1) Bloom's taxonomy components for which teachers ask pupils to name, state, define, etc. Using terms such as classify, differentiate, and identify, etc., the teachers' second-order assessment questions examine the students' understanding of the learning content that comprises the level two taxonomy components. In only a few instances did teachers evaluate students' knowledge application based on the level three Bloom's taxonomy components. It was noted that this was an application of the formula for determining power using various examples or circumstances. According to the study's findings, the only assessment question utilised by teachers, based on their interview responses and classroom observations, that falls into this category was asking students to perform some calculations on a different learning activity.

The teachers' evaluation may thus be summed up as being of a behavioural nature. For the fact that the questions are based on the learning content taught by the teachers in class, formative and summative examinations are created and centred on evaluating the students' ability to remember and recall the learning content. This has supported the claims of scholars such as Thompson (2011) and Ogunode et al, (2021) that secondary school teachers in Nigeria, like their elementary school counterparts, are relegated to the role as curriculum messengers in the education system. According to the study's findings, instructors are neither the individuals who reflect on educational activities nor those who control educational policy.

Conclusion

The study considers the basic and foundational level of education and more importantly the first science encountered by formal school learners in the country. It raised concern to the role of critical thinking and its possible constraints in the application of Bloom's taxonomy in the teaching and assessment in Nigeria. Teachers interviewed did not manage to understand and describe the adequacy of Bloom's taxonomy for critical thinking. They could not provide any evidence of concern for critical thinking in their lesson statement of objectives, teaching and assessment strategies using the taxonomy. In fact, their understanding on how critical thinking could be assessed in the evaluation process particularly using the last three higher order levels of Bloom's taxonomy proved to be grossly inadequate. Adequate preparations and provisions for the preservice and in-service teacher training, therefore, need to be made in line with the principles and requirements of the Bloom's taxonomy of teaching and learning for promoting critical thinking in learners.

Acknowledgement

References

Ab Kadir, M. (2007). Critical thinking: A family resemblance in conceptions. *Journal of Education and Human Development.* 1(2), 1-11.

Aboluwodi, A. (2016). Imperative of teaching critical thinking in higher institutions in Nigeria. *Journal of Teaching and Teacher Education,* 4(1), 9-15.

Adedoyin, O.B. (2020). Qualitative Research Method, (PDF) Qualitative Research Methods (researchgate.net).

Anderson L.W., Krathwohl D.R., Airasian P.W. (2001). A taxonomy for learning, teaching, and assessing: a revision of bloom's taxonomy of educational objectives. Complete edition. Longman, New York.

Baddeley, A. (2007). *Working memory, thought and action*. Oxford, New York.

Bissell, A. N. and Lemons. P. P. (2006). A New Method for Assessing Critical Thinking in the Classroom. *BioScience.* 56 (1), 66-72.

Bloom, B. S. (Ed.). (1984). Taxonomy of educational objectives. Book 1: Cognitive domain. White Plains, NY: Longman.

Bloom, B., S. (1956). Taxonomy of educational objectives: Cognitive domain. NY: Longman.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77-101.

Brown, T. (2004). Bloom's taxonomy: Bloom's taxonomy and critical thinking. In J. L. Kincheloe & D. Weil (Eds.), *Critical thinking and learning*. An encyclopedia for parents and teachers, pp 77-82. Westport, CT: Greenwood.

Bucy, M. C. (2006). Encouraging critical thinking through expert panel discussions. *College Teaching.* 54(2), 222-224.

Constantinou, C., Georgiou, M., Perdikogianni, M. (2017). A comparative method for themes saturation (CoMeTS) in qualitative interviews. Qualitative Research. 1-18

Enoh A. O. (2013). *Main Current in Nigerian Educational Thought.* Midland Press, Jos.

Cotter, E.M. & Tally, C. (2009). Do critical thinking exercises improve critical thinking skills? *Education Research Quarterly,* 33(2), 3-14.

Creswell, J. W. (2014). Qualitative inquiry and research design: Choosing among five approaches (4th ed.). Sage Publications, USA.

Ezechi, N. G. & Ogbu, C. C. (2017). Science education in Nigeria: Challenges and the way forward. *International Journal of Progressive and Alternative Education,* 4 (1), 2-11.

Facione, P. A. (1990). Critical thinking: A statement of expert consensus for purposes of educational assessment and instruction. Research Findings and Recommendations. *Newark, DE: American Philosophical Association. (ERIC Document Reproduction Service No. ED3155423).*

Ikuenobe, P. (2001). Teaching and assessing critical thinking abilities as outcomes in an informal logic course. *Teaching in Higher Education,* 6(1), 19-35.

Jonassen, D. H. (2010). *Learning to solve problems: A handbook for designing problem-solving learning environments.* Taylor & Francis.

Kalusi, J.I. (2017). Reconstructing Teacher Education for National Development in Nigeria: Onyerisara Ukeje's Philosophical Ideas to the Rescue. *Nigerian Journal of Educational Philosophy, 27 (1), ISSN:0795-0124,* 270-278

Krathwohl DR. (2002). A revision of bloom's taxonomy: an overview. *Theory Practice. 41(4):212–218. DOI: 10.1207/s15430421tip4104_2*

Kurfiss, J. G. (1988). Critical thinking: theory, research, practice, and possibilities. Washington, D.C. : Association for the Study of Higher Education.

Lemov, D. (2010). Teaching like a champion: 49 techniques that put students on the path to college. San Francisco, CA: Jossey-Bass.

Merriam, S. (2009). Qualitative research: A guide to design and implementation. CA: Jossey-Bass, San Francisco.

Mike, G. (2018): How to use Bloom's Taxonomy in the Classroom. A Complete Guide. Learning Science.com, USA.

Newton, P.M.; Da Silva, A. & Peters, L.G. (2020). A Pragmatic Master List of Action Verbs for Bloom's Taxonomy. Frontiers Education. 5 (107), DOI: 10.3389/feduc.2020.00107

Ogunode, N.J. et al (2021). Problems facing science teachers in public secondary schools in Nigeria and way forward. *International Journal of Discoveries and Innovations in Applied Sciences,* 1 (5), 118-129*, 355885840. https://www.researchgate.net/publication/*

Olatunji, M. O. (2017): Critical Thinking in Nigeria's Pre-Service Teachers Education: A Philosophical Investigation, J*ournal of Teacher Education and Educators, 6 (2), 205-221.*

Paul, R. W. (1990), Critical thinking: What, why, and how. In by A. J. A Rohnert Park (ed.) *Critical thinking: What every person needs to survive in a rapidly changing world.* Chapter 4: [45-56].

Paul, R. W. (1993). The logic of creative and critical thinking. *American Behavioral Scientist,* 37 (1), 21-39.

Shakirova, D.M. (2007). Technology for the Shaping of College Students' and Upper-Grade Students' Critical Thinking. *Russian Education & Society,* 49 (9), 42-52. *DOI: 10.2753/RES1060-9393490905*

Shaunessy, E. (2005). *Questioning strategies for teaching the gifted*. Prufock Press Inc. Waco, Texas.

Thompson, R., & Bolin, G. (2011). Indicators of Success in STEM Majors: A Cohort Study. Journal of College Admission, 212 (1), 18-24. https://eric.ed.gov/?id-EJ939062.

Yin, R. (2013). Study research: Design and methods (5th ed.). Thousand Oaks, CA: Sage.