Available online at: https://journals.researchsynergypress.com/index.php/ijrse
International Journal of Research in STEM Education (IJRSE)
ISSN 2721-2904 (Online) | 2721-3242 (Print)
Volume 4 Number 1 (2022): 64-82

Analysis of Intellectual Demands Embodied in The Learning Objectives Prescribed for Mathematics and Science Components of The Teacher Training Manual

Ayoade Ejiwale Okanlawon[1]
[1]Osun State University, Osogbo, Nigeria

Abstract
Higher-order thinking is as an important skill needed to function effectively in 21st century classrooms. Consequently, teacher professional development should be geared towards assisting teachers in acquiring skills needed to plan intellectually demanding classroom activities for their students. Engaging teachers in activities such as inquiry-oriented discussion, investigation, experimentation with new classroom practices, expansion of pedagogical knowledge, and acquisition of new teaching skills and development of innovative approaches to teaching is an effective way of promoting higher-order cognitive skills. However, information about the quality of the teacher training manual in terms of its intellectual demands are lacking. Hence, the need for this study becomes imperative. Existing prescribed learning objectives for Mathematics and Science components of the manual which served as the data source were analyzed by using qualitative content analysis method. The findings showed that the majority of the learning objectives prescribed in the teacher training manual clustered around lower-order cognitive skills. In addition, reasonable proportion of learning objectives prescribed for the Mathematics component emphasized higher-order cognitive skills more than the Science component. Further results revealed that the subject-matter content is more intellectually demanding than the aspect of the manual focusing on pedagogical knowledge. These have implications for the prescription of learning objectives in teacher training manual and planning of high-quality teacher professional development programme.

Keywords: *Learning objectives, Intellectual demands, higher-order cognitive skills, teacher training manual, teacher professional development*

INTRODUCTION

In Nigeria, the Colleges of Education established by the State and Federal Governments are saddled with the production of teachers for the nursery and primary schools. Unarguably, an academic programme offered by these teacher training institutions is not enough to sustain them in the face of changing teachers' instructional practices (Cheng, Tang & Cheng, 2012; Bowman, Vongkulluksn, Jiang & Xie , 2020). Therefore, for the newly employed graduates into teaching profession to successfully implement primary school curriculum, there is need to put into place continuous professional development programmes. Guskey (2002) and Hubers, Endedijk and van Veen (2020) conceived professional development as opportunities offered to practising teachers to develop new knowledge, skills, approaches and dispositions to improve their effectiveness in the classroom. Some professional development programmes available in Nigeria for primary school teachers are in form of workshops, conferences, seminars focusing on knowledge of the subject content areas and methodological skills of delivery. According to Cheng, Lu, Xie, & Vongkulluksn (2020) quality can be built into such training programmes when they are designed to address teachers' current pedagogical needs and interest.

The decline in primary school pupils' performance in the state examinations which was directly linked to instructional in effectiveness makes education stakeholders to wonder about the quality of teachers

Corresponding author
drokanla@gmail.com
DOI: https://doi.org/10.31098/ijrse.v4i1.775

in primary schools. As evident from the poor performance of primary school teachers in a statewide examination (based on primary six standard) conducted by a state in Northern part of Nigeria, it was observed that primary school teachers are a little bit better than their pupils in terms of their knowledge of the subject matter. If pupils are not performing well, then teachers must be partly responsible (Weisberg et al. 2009; Marshall, 2012) because teachers in their classrooms have the greatest influence on student learning and achievement (Darling-Hammond, 2010; Stronge, Ward & Grant, 2011).

With the strong connection between instructional effectiveness and pupils' achievement as established by research (Haertel & Rothstein, 2012; Rice, 2012), equipping teachers with pedagogical knowledge and skills becomes the priority of the various subject associations and the Ministry of Education through its agencies (e.g. State Universal Basic Education Board, SUBEB). To equip Nigerian primary school teachers with the skills and competencies needed in their daily classroom practices, SUBEB (2021) in collaboration with a team of subject-content specialists drawn from the two Faculties of Education in Nigerian universities developed a manual for the retaining of primary school teachers in the state.

The developed manual indicates learning objectives to be pursued, defines the nature, scope and sequence of the content, specifies teaching and learning activities that will be used to deliver the content, selects instructional materials and indicates methods that will be used by the facilitator and trainees to determine whether the learning objectives have been met or not. Out of all these components of the manual, learning objectives are taken as a unit of analysis in providing information regarding the intellectual demands in the mathematics and science components of the manual as it was done in previous researches (e.g., Lee, Kim, & Yoon, 2015; Wei, 2020; Elmas et al.,2020) This is because they are essential to the learners, instructors and curriculum planners in describing observable and measurable skills, knowledge and values that learners should be able to demonstrate upon completing a module or lesson (Simon & Taylor,2009). In addition, it provides a reliable foundation upon which the remaining components are built. For example, learning objectives serve as basis by which content is outlined, teaching activities are planned, learning and instructional materials are selected and assessments are prepared (Tyler, 1949). Learning objectives are also beneficial to the learners because they provide information about the content to be learnt and assist learners in making appropriate choice of study method (Konig, Bremenrich-Vos, Buchholtz, & Glutsch, 2020).

In recent years, there are numerous studies focusing on examination of the extent of intellectual demands that manifest in examination questions, end-of-chapter/text exercises, games and the learning objectives pursued within officially prescribed curriculum and other curriculum materials (e.g. textbooks). For instance, Elmas et al. (2020) compared the cognitive levels of learning outcomes in science curricula in different countries/regions. Following the same research terrain, Wei (2020) examined the changing tendencies of the cognitive levels of learning objectives prescribed in Chinese Science Curricula over a period of time. In a related study, Baghaei et al (2020), compared the cognitive demands manifested in the listening and reading components of two different standardized tests. In addition, following a different research path, Hari (2018) examined the degree of intellectual demands embodied in different psychotherapeutic games. As evident from these previous studies, the interest of earlier researchers tends towards intellectual demands of teaching and learning materials (curriculum, textbook, games) designed for student learning and not towards materials for Teacher Professional Development. Taking this into consideration, the authors decided to examine the extent of intellectual demands embodied in the learning objectives prescribed for the science and mathematics components of the teacher training manual designed for the improvement of teachers' professional learning. To achieve the study's objectives, the following research questions are formulated:

(1) What are the cognitive demands of the learning objectives prescribed in the School-Based training manual for primary school teachers?
(2) What are the differences in the cognitive demands of the learning objectives prescribed for the Mathematics and Science content areas of the teacher training manual?
(3) What are the differences in the cognitive demands of the learning objectives prescribed for the subject-matter content and pedagogical content areas of the of the teacher training manual?

It is expected that stakeholders in teachers' professional development will benefit immensely from this study since to the best of authors' knowledge there is no existing research in Nigeria at the moment that investigates the intellectual demands of the learning objectives prescribed in the manual. As a result, it will be difficult for the State Universal Basic Education Board, Inspectorate Division of the Ministry of Education and workshop facilitators to ascertain the extent to which the manual is useful to the teacher trainees in building their higher-order thinking skills, an essential ingredient needed to function effectively in 21st century science and mathematics classrooms (Hobbins et al, 2020). Globally, concerted efforts are being made by teacher training institutions to incorporate training that demands higher-order thinking skills into teacher preparation and professional development Bijesterbosch, 2018).

The SUBEB Training Manual for Public Primary School Teachers

The content of the SUBEB Training Manual for public primary school teachers is divided into nineteen modules: Literacy, Reading, Mother tongue, Teaching-perceived difficult concepts in mathematics, Methods/strategies of teaching mathematics, Open educational resources and teaching materials, Basic science and technology, Science and societal development, Making science learning easy, Innovative teaching and learning of social studies/Civic Education, Reflective teaching, Emergency issues in primary social studies curriculum, Classroom management, Emergency response in school, School safety, Understanding how children learn, Definition and meaning of special education, Specific methodology in teaching special needs pupils in regular schools and Inclusive special education. Each of these modules is carefully structured along the following sections: objectives, case-study, design/illustration, learning points, exercises and things to remember.

Only six modules (4, 5, 6, 7, 8, and 9) out of these modules focus on Science and Mathematics. The importance attached to the teaching and learning Basic Science and Technology in the recent time serves as a rationale for focusing on the science and mathematics components of the manual in the study. For citizens to fully participate in the constantly changing society, acquisition of scientific and technological knowledge and skills is essential (Brown-Acqaye (2001). With the relatively low enrollment of students seeking admission to pursue a career in science and technology, there is urgent need to pay attention to the teaching of science and technology at the elementary level.

Each module is further organized into distinct units with a view to facilitating its implementation by the facilitators. The modular units outline broad areas of knowledge and understanding, which aim at exposing primary school teachers to the subject-content and the methodological skills of delivery. Each modular unit includes several relevant topics (on content knowledge and pedagogical knowledge) which form the basic contents to be covered during training which is specifically designed for Teachers Professional Development.

Using the Revised Bloom's Taxonomy (RBT) in formulating and assigning cognitive demand to learning objectives

To analyse the intellectual demands embodied in the learning objectives prescribed for the teacher training manual, the study's theoretical framework is built on the Revised Bloom's Taxonomy (RBT) of educational objectives which Bloom et al. (1956) originally classified learning domain into three: Cognitive, Affective, Psychomotor. Each of these domains comprised categories which are ordered in degree of complexity. The original Bloom's Taxonomy provided six hierarchical levels that described the cognitive domain as knowledge, comprehension, application, analysis, synthesis and evaluation.

The bottom level (lower-order cognitive skills), constitutes the first two levels and it includes the most basic cognition and the highest level (higher-order cognitive skills), represents the remaining four levels and it includes the most intellectual and complicated thinking (Freeman, Haak, Wenderoth, 2011). It is this classification scheme that was adopted in analysis learning objectives in this study. The above mentioned two extremes are also labeled as "meaningful" and "rote learning" (Anderson et al, 2001) or "deep" and "surface learning" (Harlen & James, 1997). The idea behind this theory is that students cannot be successful in applying higher-order thinking to a topic until they have first mastered a ladder of rudimentary tasks. In other words, each category (or 'level') must be mastered by the students before progressing to next.

In 2001, Bloom's Colleagues, Lorin Anderson and David Krathwohl reviewed and modified the original Bloom's Taxonomy of Educational objectives by introducing the following changes: (1) renaming the terms knowledge and comprehension as remembering and understanding respectively (2) changing the names in the six levels from noun to verb forms (for instance analysis to analyze) (3) placing creating at the highest level of the taxonomy and moving evaluating down to the second highest level. With these modifications, the Anderson and Krathwohl's (2001) revised Bloom's taxonomy became: Remember, Understand, Apply, Analyze, Evaluate, Create.

In addition to those modifications, RBT advances two taxonomy dimensions: knowledge dimension (Table 1) and cognitive dimension (Table 2). These two dimensions interact to create a Cognitive Process Dimension and Knowledge Dimension Matrix with which learning objectives can be analysed (Table 3).

Table 1: The major divisions and subdivisions of the knowledge dimension of RBT

Major Division	Sub-Division	Example(s)
Factual knowledge – the basic elements students must know to be acquainted with a discipline or solve characteristics of a test	1.1 Knowledge of terminology Learning objective, assessment 1.2. Knowledge of specific details and elements	Some desirable problems in it.
Conceptual knowledge – the interrelationships among the basic elements within a larger structure that enable Teaching and learning principles them to function together objectives, learning theories	2.1. Knowledge of classifications and categories 2.2 Knowledge of principles and generalizations 2.3 Knowledge of theories, models, and structures	The nature of teaching Structure of learning Differentiating instruction
3. Procedural knowledge – how to do something, methods of inquiry, and criteria for using skills, algorithms, techniques, and methods	3.1 Knowledge of subject-specific skills and algorithms. 3.2 Knowledge of subject-specific techniques and methods 3.3 Knowledge of criteria for determining when appropriate procedures are organized	Questioning techniques The criteria used to determine appropriate procedures are organized when to utilize a specific instructional strategy The criteria used to determine when to utilize a specific instructional strategy
4. Meta-cognitive knowledge – knowledge of cognition in general as well as awareness and knowledge of one's own cognitive	4.1 Strategic knowledge 4.2 Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge 4.3 Self-knowledge	Knowledge needed in breaking a complex task into sub-skills to simplify its teaching Knowledge of the intellectual demands of different test items Awareness of one's competence level

Table 2: The cognitive process dimension of RBT

Levels of cognitive ability	Learning objectives formulated at this level…	Examples of cognitive processes involved
Remember	covers learners' ability to recall or remember the information	Quote, define, duplicate, list, memorize, recall, repeat, reproduce, state
Understand	covers learners' ability to explain ideas or concepts	Restate, describe, exemplify, extend, explain, identify, recognize, report, select, translate, paraphrase
Apply	covers learners' ability to use the information in a new way	Execute, demonstrate, dramatize, employ, illustrate, interpret, operate, manipulate, compute, solve, use, relate
Analyze	covers learners ability to distinguish between the different parts	Divide, compare, contrast , criticize, differentiate, discriminate, distinguish, examine, breakdown, test
Evaluate	covers learners' ability to justify a stand or decision	Decide, appraise, justify, defend, judge, select, support, value, assess
Create	covers learners' ability to create a new product or point of view	Invent, construct, compose, design, develop, formulate, modify, devise

METHOD

In resolving the research questions, the learning objectives prescribed in the School-Based Training Manual (SBTM) for public primary school teachers in Oyo State (Nigeria) were subjected to documentary analysis. Through this process, the prescribed learning objectives were assigned to appropriate intersecting cells (after being coded) in the Interactive Bloom's Taxonomy Chart (IBTC) which comprised 24 cells (Table 3).

The coding was carried out by the first two authors based on the pre-existing coding system. The eligibility of the two coders was based on their experiences in similar task when they serviced in the Faculty Quality Assurance Committee. The coding procedure involves five distinct stages. The first stage requires reading and rereading of individual learning objective with a view to locating the action verb and noun in each of the learning objectives (Table 4). In the second stage, the action verb as expressed in a learning objective was classified into one of the six hierarchical cognitive process dimension divisions. The next stage involves placement of the noun component of each learning objective into one of the four knowledge dimension categories. The fourth stage involves assigning code to individual learning objective using predetermined codes (Table 3). The last stage requires putting coded learning objectives into appropriate interacting cells (Table 6)

Table 3: Interactive Bloom's Taxonomy Chart

Interactive Bloom's Taxonomy Chart		**The Cognitive Process Dimension**					
		Remember M	**Understand N**	**Apply O**	**Analyze P**	**Evaluate Q**	**Create R**
The Knowled	**Factual 1**	M1	N1	O1	P1	Q1	R1
	Conceptual 2	M2	N2	O2	P2	Q2	R2
	Procedural 3	M3	N3	O3	P3	Q3	R3
	Metacognitive 4	M4	N4	O4	P4	Q4	R4

Table 4: Breaking down learning objectives into verb and noun phrase components

Manual Component	S/N	Learning Objective	Verb Phrase Component	Noun Phrase Component	Code	Code label
Mathematics Component	1	Discuss how to improvise different learning materials for mathematics	Discuss how to	improvise different learning materials for mathematics	**N3**	Understanding Procedural Knowledge
	2	Explain the properties of both 2-Dimentional and 3-Dimentional shapes	Explain the	properties of both 2-Dimentional and 3-Dimentional shapes	**N2**	Understanding Conceptual Knowledge

Science Component	1	Compare a mosss and a fern	Compare	a moss and a fern	**N1**	Understanding Factual Knowledge
	2	Describe the significance of using improvised materials to teach science and technology	Describe the significance of	using improvised materials to teach science and technology	**N3**	Understanding Procedural Knowledge

Table 5: Description of code

Code	Code label	Description
N_1	Understanding procedural knowledge	Learning objective in this category demands students' ability to explain, differentiate, connect a concept learnt previously with incoming knowledge and perform certain activities in accordance with certain guidelines or laydown principles.
N_2	Understanding conceptual knowledge	Learning objectives categorized in group demand students' ability to describe, restate, translate, exemplify and incorporate a new idea into an established scheme or re-organize an existing scheme to fit a new idea.
N_3	Understanding factual knowledge	Learning objectives categorized in this group require students to extend ideas, describe, differentiate, paraphrase and demonstrate possession of knowledge of terminologies and specific facts.

Table 6: Assigning learning objectives into cells of the Interactive Bloom's Taxonomy Chart

Interactive Bloom's Taxonomy Chart		**The Cognitive Process Dimension**					
		Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
The Knowledge Dimension	**Factual**	Enumerate the roles of the teacher in the teaching of basic and technology	Describe the various importance of science				Build numerals up to 99 with Abacus
	Conceptual	State the principles of play-way method	Explain the properties of 2-Dimensional and 3-Dimensional shapes	Teach concept of area of some 2-dimensional shape	Differentiate compound from a mixture		

			Describe how science clubs aid the learning of basic science and technology				
	Procedural						
	Metacognitive						

Prior to the actual coding, a segment of the learning objectives in the teacher training manual was independently coded by two researchers following the aforementioned stages. Upon the completion of the initial coding, they engaged in an interactive session to determine the frequency at which coding coincided (i.e. how often the two coders assigned the same code to the same learning objective) between coding made at different occasions by a single coder (intra-rater reliability) and between the two coders (inter-rater reliability). Thereafter, variations in coding between the two coders were discussed and adjusted to reach a high degree of inter-coder agreement. Ahead of the discussion, the learning objectives were independently coded twice by each of the two coders with a two-week time interval and the degree of consistency between the two coding attempts was estimated. The researchers believed that engaging the coders in an inter-coder agreement discussion is a necessary measure to enhance their understanding of the coding process.

Having acquired the coding skills, the actual coding was carried out in which the coding rubric was then applied to the whole learning objectives (n=76) prescribed in the teacher training manual following the stages earlier highlighted. Upon the completion of the actual coding process, inter-coder reliability was calculated to determine if there was an agreement among the two codings. The Cohen's Kappa values (.65) and percentage agreement (84%) were obtained which indicated a substantial agreement among the two codings.

RESULTS

In consonance with the previous studies that employed RBT as analytical framework, the results of the analysis conducted using frequency counts and percentages are presented in accordance with the research questions as follows:

Revealing intellectual demands embodied in the learning objectives prescribed in the teacher training manual based on RBT

Data analysis has shown that large proportion of the learning objectives prescribed in the teacher training manual clustered around the lower-order cognitive skills. As shown in Table 7, 28.9 % of the learning objectives constituted HOCS while 71.1 % constituted LOCS. The low proportion of HOCS is attributed to the fact that there were no learning objectives prescribed at the following learning levels:

P1 (Analysing factual knowledge), Q1 (evaluating factual knowledge), Q2 (evaluating conceptual knowledge), Q3 (evaluating procedural knowledge), R3 (creating procedural knowledge), P4 (Analysing metacognitive knowledge), Q4 (evaluating metacognitive knowledge) and R4 (creating metacognitive knowledge). However, with the learning objectives being formulated at the learning levels of P2 (Analysing conceptual knowledge, 9.2%), P3 (Analysing procedural knowledge, 1.3%), R1 (creating factual knowledge, 2.6%) and R2 (creating conceptual knowledge, 2.6%), there was a little effort being made by the manual developers to promote HOCS.

Table 7: Distribution of learning objectives (n=76) prescribed in the training manual within the 24cells of the IBTC

	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**	**No. of knowledge items**
Factual	19(25.0)	8(10.5)	4(5.3)	0	0	2(2.6)	33(43.4)
Conceptual	9(11.8)	6(7.9)	6(7.9)	7(9.2)	0	2(2.6)	30(39.5))
Procedural	2(2.6)	6(7.9)	0	1(1.3)	0	0	9(11.8)
Metacognitive	0	4(5.3)	0	0	0	0	4(5.3)
Number of cognitive items	30(39.5)	24(31.6)	10(13.2)	8(10.5)	0	4(5.3)	**76**

Percentages are shown in parentheses (%): Percentage of LOCS is 71.1% Percentage of HOCS is 28.9%

Comparing the intellectual demands of mathematics and science content areas of the training manual based on RBT

As shown in Tables 8, 9 and 10, M1 (Remembering factual knowledge), M2 (Remembering conceptual knowledge), M3 (Remembering procedural knowledge), N1 (Understanding factual knowledge), N2 (Understanding conceptual knowledge), N3 (Understanding procedural knowledge), N4 (Understanding metacognitive knowledge) and P2 (Analysing conceptual knowledge) are learning levels that featured in both Mathematics and Science content areas at varying percentages. For instance, when comparing the two content areas in terms of learning level, M1 (Remembering factual knowledge), a lower-level learning level, with 46.7% is the dominant learning level in the science component. On the other hand, mathematics content area has P2 – Analysing conceptual knowledge (13.0%) as the dominant learning level (Table 10). As further revealed by the analysis (Table 10), the mathematics component also included learning objectives prescribed at the following learning levels: O1 – Applying factual knowledge (8.7%), O4 – Applying metacognitive knowledge (6.5%), P3 – Analysing procedural knowledge (2.2%), R1 – creating factual knowledge (4.3%) and R2 – creating conceptual knowledge (4.3%). These learning levels that are considered as the upper-level categories were absent in the science content area of the teacher training manual. With this result, the mathematics component is more intellectually demanding than the science component of the training manual. As far as the learning objectives are concerned, a significant proportion (50.0%) of learning objectives prescribed for the mathematics component emphasized HOCS (Table 8) as compared to the science component with only 6.7% of its learning objectives focusing on HOCS (Table 9).

Table 8: Distribution of learning objectives (n=46) prescribed for the Mathematics component of the training manual within the 24 cells of the IBTC

	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**	**No. of knowledge items**
Factual	5(10.9)	4(8.7)	4(8.7)	0	0	2(4.3)	15(32.6)
Conceptual	5(10.9)	3(6.5))	5(10.9)	6(13.0)	0	2(4.3)	21(45.6)
Procedural	1(2.2)	5(10.9)	0	1(2.2)	0	0	7(15.3)
Metacognitive	0	0	3(6.5)	0	0	0	3(6.5)
Number of cognitive Items	11(24.0)	12(26.1)	12(26.1)	7(15.2)	0	4(8.7)	**46**

Percentages are shown in parentheses (%): Percentage of LOCS is 50.1% Percentage of HOCS is 50%

Table 9: Distribution of learning objectives (n=30) prescribed for the Science component of the training manual within the 24 cells of the IBTC

	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**	**No. of knowledge items**
Factual	14(46.7)	4(13.3)	0	0	0	0	18(60.0)
Conceptual	4(13.3)	3(10.0)	1(3.3)	1(3.3)	0	0	9(29.9)
Procedural	1(3.3)	1(3.3)	0	0	0	0	2(6.6)
Metacognitive	0	1(3.3)	0	0	0	0	1(3.3)
Number of cognitive items	19(63.3)	9(29.9))	1(3.3)	1(3.3)	0	0	**30**

Percentages are shown in parentheses (%): Percentage of LOCS is 93.3% Percentage of HOCS is 6.7%

Table 10: Percentages of learning objectives at various learning levels for Mathematics and Science components of the Manual

Manual Component	**Learning Level (Interacting Cells)**													
	M1	**M2**	**M3**	**N1**	**N2**	**N3**	**N4**	**O1**	**O2**	**O4**	**P2**	**P3**	**R1**	**R2**
Mathematics Component	10.9	10.9	2.2	8.7	6.5	10.9	0	8.7	10.9	6.5	13.0	2.2	4.3	4.3
Science Component	46.7	13.3	3.3	13.3	10.0	3.3.	3.0	0	3.3	0	3.3	0	0	0

Comparing the intellectual demands of the Subject-matter Knowledge (SMK) and Pedagogical Knowledge (PK) areas of the training manual based on RBT

As shown in Table 11,12 and 13 , the following learning levels considered as upper-level categories (P2 – Analyzing conceptual knowledge, P3 – Analyzing procedural knowledge, R1 – creating factual knowledge and R2 – creating conceptual knowledge) did not appear in the pedagogical content portion of the training manual. Yet, these learning levels were featured in the subject-matter content area of the manual but at lower percentages.

On the other hand, M3 (Remembering procedural knowledge – 5.4%), N3 (Understanding procedural knowledge – 10.8%) and N4 (Understanding metacognitive knowledge – 10.8%) which were categorized as lower-learning levels featured in the pedagogical content area of the training manual (Table 13). These learning levels were not captured when prescribing learning objectives for subject-matter content area by the manual developers.

Despite the absence of some categories of learning levels in both content areas, they still commonly featured in the following learning levels at varying proportions: M1 (Remembering factual knowledge – 20.5% for SMK; 29.7% for PK), M2 (Remembering conceptual knowledge – 12.8% for SMK; 8.1% for

PK), N1 (Understanding factual knowledge – 5.1% for SMK; 21.6% for PK), N2 (Understanding conceptual knowledge – 10.3% for SMK; 5.4% for PK), O1 (Applying factual knowledge – 5.1% for SMK; 5.4% for PK) O2 (Applying conceptual knowledge – 12.8% for SMK; 27.0% for PK). As evidently shown in Table 11 , the dominant learning levels in the subject matter content area are M1 (Remembering factual knowledge – 20.5%) and P2 (Analysing conceptual knowledge – 20.5%). In contrast, the pedagogical content area has M1 (Remembering factual knowledge – 29.7%), N1 (Understanding factual knowledge – 21.6%) and O2 (Applying conceptual knowledge – 27.0%) as the dominant learning levels (Table 12).

As revealed in Tables 11 and 12, the lower-order cognitive skills (LOCS) were dominant in both content areas. However, the subject-matter content area is more intellectually demanding than the pedagogical content area. This is because the cognitive processes required in learning the subject-matter content area of the teacher training manual are (1) analyzing both conceptual and procedural knowledge (2) creating both factual and conceptual knowledge.

Table 11: Distribution of learning objectives (n=39) prescribed for the Subject matter component of the training manual within the 24 cells of the IBTC

	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**	**No. of knowledge items**
Factual	8(20.5)	2(5.1)	2(5.1)	0	0	2(5.1)	14(35.8)
Conceptual	5(12.8)	4(10.3)	5(12.8))	8(20.5)	0	2(5.1)	24(61.5)
Procedural	0	0	0	1(2.6)	0	0	1(2.6)
Metacognitive	0	0	0	0	0	0	0
Number of cognitive Items	13(33.3)	6(15.4)	7(17.9)	9(23.1)	0	4(10.2)	**39**

Percentages are shown in parentheses (%): Percentage of LOCS is 48.7% Percentage of HOCS is 51.2%

Table 12: Distribution of learning objectives (n=37) prescribed for the Pedagogical component of the training manual within the 24 cells of the IBTC

	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**	**No. of knowledge items**
Factual	11(29.7)	8(21.6)	2(5.4)	0	0	0	21(56.7)
Conceptual	3(8.1)	2((5.4))	1(2.7)	0	0	0	6(16.2)
Procedural	2(5.4)	4(10.8)	0	0	0	0	6(16.2)
Metacognitive	0	4(10.8)	0	0	0	0	4(10.8)
Number of cognitive Items	16(43.2)	18(48.6)	3(8.1)	0	0	0	**37**

Percentages are shown in parentheses (%): Percentage of LOCS is 91.8% Percentage of HOCS is 8.1%

Table 13: Percentages of learning objectives at various learning levels for Subject-matter content area and Pedagogical content areas of the Manual

Manual Component	**Learning Level (Interacting Cells)**												
	M1	**M2**	**M3**	**N1**	**N2**	**N3**	**N4**	**O1**	**O2**	**P2**	**P3**	**R1**	**R2**
Subject-matter Knowledge	20.5	12.8	0	5.1	10.3	0	0	5.1	12.8	20.5	2.6	5.1	5.1

Pedagogical Knowledge	29.7	8.1	5.4	21.6	5.4	10.8	10.8	5.4	27	0	0	0	0

DISCUSSION AND CONCLUSION

This study attempts to analyse the intellectual demands embodied in the learning objectives prescribed for mathematics and science components of the teacher training manual. By subjecting the learning objectives to content analysis, the study revealed that the focus is more on cognitive processes requiring lower-order cognitive skills. The comparison of this finding with other similar studies (which reported that current classroom practices do not sufficiently target HOT) is not in tandem with the teacher training standards set for the promotion of higher-order thinking skill by the Teachers Registration Council of Nigeria (TRCN). The standard calls for less emphasis on lower-order learning objectives on the ground that they hinder meaningful learning and development. Evidences from the previous studies (e.g., FitzPatrick & Henry, 2015; Schul and FitzPatrick, 2016) revealed that students who have been deprived of exposure to a demanding, challenging, thinking curriculum do perform poorly in the task requiring of higher-level thinking.

Another main finding that emerged from this study is the fact that the mathematics component of the training manual is more intellectually challenging than the science component. This finding could be explained in terms of the nature of mathematics contents which involve computations and application of theories. The in-service teachers are subjected to different learning activities (tasks) such as finding the LCM/HCF of two or more numbers, building up numerals up to 99 with Abacus, calculating the volume of some 3-D shapes, teaching the concept of area of some 3-D shapes, calculating the volume of some 3-D shapes and constructing 3-D geometrical shapes. On the contrary, the training manual developers prescribed learning objectives at lower cognitive learning level for the science component as against Kim, Xie and Cheng's (2017) prescription of learning activities for teachers during professional development programme. They suggested that a hierarchy of learning activities gradually progressing from lower learning tasks to higher-order learning tasks should feature during training session. By engaging teachers as learners in higher-order thinking activity, they are better able to make sense of what they learn, link incoming knowledge with previously acquired knowledge and store newly constructed knowledge in their cognitive structures (Wijnen, van der Molen, & Voogt, 2021). A plausible reason that might be responsible for the above finding is connected with the teacher training programme received by the in-service primary school teachers. With the scrapping of teachers training colleges (institutions saddled with the responsibility of awarding Teacher Grade II Certificate), the new category of teachers now employed in the primary schools in Nigeria are National Certificate of Education (NCE) holders who were not trained to teach all primary school subjects. In addition, only few of them are specialists in mathematics and science at NCE level. Taking these two factors into consideration, the teacher training manual developers, based the contents of the training manual on the Primary Six Basic Science Curriculum from which lower-cognitive level of learning objectives were prescribed in the teacher training manual.

Regarding the comparison of the subject-matter content and pedagogical content areas of the training manual in terms of the intellectual demands, the result revealed that the subject-matter content is more intellectually demanding than the pedagogical content areas of the manual. This is due to the fact that learning objectives at upper-level categories of learning (e.g. analyzing conceptual knowledge, analyzing procedural knowledge, and creating factual and conceptual knowledge) were prescribed for the subject-matter content component of the manual.

As the subject-matter content area is more cognitive demanding than the pedagogical content component of the teacher training manual, the expected integration of content knowledge into pedagogical components that is needed to generate important knowledge for effective teaching would be negatively affected. With the dissonance between the subject matter and pedagogical knowledge in terms of the intellectual demands, both knowledge types risk being stored with little reference to each other in largely unconnected cognitive structure. In such a situation, applicability of knowledge will be seriously hindered because the cognitive structure which is expected to be a web of associated knowledge pieces is said to be fragmented (Snowman & Beihler, 2006). The concurrent exposure of the in-service primary school teachers to both content and pedagogical knowledge by the same facilitator is intentionally designed to produce competent teachers. It is observed by Harr, Eichler and Renki (2014) that the methodology courses mounted in teacher training institutions sparingly connected content knowledge with the pedagogical knowledge, thereby leaving individual teachers to build up the necessary connections themselves. The resultant effect is accumulation of inert knowledge which rendered teachers incompetent.

Regardless of the backgrounds and qualifications of the in-service primary school teachers who were exposed to this manual, the manual developers ought to have formulated learning objectives involving higher-order cognitive processes for the pedagogical content area. Such objectives among others include the following: generating a series of learning activities for attaining pre-determined objectives, proposing a set of techniques for diagnosing students' learning problem, modifying instructional strategies based on students' level of understanding, demonstrating ability to access quality of instructional materials, and deciding when it is appropriate to use teacher-directed or student-initiated method. Learning objectives requiring higher-order cognitive process for their attainment are likely to force the facilitators to embrace student-initiated instruction (Toy & Ok, 2012). This result could also serve as a motivating factor for initiating the process of teacher training manual review with a view to formulating learning objectives at higher-order level of cognitive domain and thereby improve the quality of learning resources for teachers. Failure to develop adequate reasoning skills during the professional development programme of this nature may have a profound and lasting effect on their classroom practices.

Implications for teacher professional development and teacher learning

In researchers' view, important implications can be drawn for teacher profession development and teacher learning. This is because an understanding of the study's findings will help all stakeholders that are connected to the teachers' professional development. The analysis presented in this paper indicates that the proportion of lower-order learning objectives is higher than higher-order learning objectives in the teacher training manuals. Three serious problems might arise from this.

First, facilitators might be oriented towards adopting teacher-centred instructional strategy during the training session. Often connected with lower-order learning objectives are teacher-directed instructional strategies where learners are passive recipient of knowledge transmitted by the instructor. Teachers tend to teach subject-matter contents through lecture method because their efforts to plan learning activities to stimulate students' higher-order thinking skills are hindered by the level of intellectual demands embodies in the learning objectives prescribed in the teacher learning resources (Vanderhook, 2020).

Second, students' approaches to learning are strongly influenced by the types of question used by the instructors to measure the degree of students' mastery of content with the dominance of lower-order learning objectives, lower-order questions will be predominantly featured during the training session. Under this condition, students often adopt a surface level approach to learning, which is characterized by memorization of fragmented facts and heavy reliance on rote learning.

Third, in relation to the second implication, large proportion of lower-order learning objectives prescribed in the teacher training manual may pose difficulty in distinguishing between the lower-order and higher-order achieving students by the facilitators. This is likely to be so because lower-order cognitive skills restricted learner to memorization/recall of acquired knowledge. Researchers (Lane & Bourke, 2016; Bijsterboch, 2018) revealed that by probing deep into students' advanced thinking skills and abilities to explain their thinking, a valid assessment yields a more complete picture of students' strengths and weaknesses. Probably, it may be difficult for the facilitators to have a complete picture of the trainees (in-service primary school teachers) because lower-order learning objectives outnumbered higher-order learning objectives in the teacher training manual.

REFERENCES

Anderson, L. & Krathwoohl. D. (2001). *A taxonomy for learning, teaching and assessing: A revision of bloom's taxonomy of educational objectives* (completed) Longman,

Anderson, L. W., Krathwohl, D. R., Airasian, P., Cruikshank, K., Mayer, R., Pintrich, P. & Wittrock, M. (2001). A taxonomy for learning, teaching and assessing: a revised of Bloom's taxonomy, New York: Longman Publishing.

Baghaei, S., Bagheri, M. S., & Yamini, M. (2020). Analysis of IELTS and TOEFL reading and listening tests in terms of Revised Bloom's Taxonomy. *Cogent Education,* 7(1), 1720939.

Bijsterbosch, E. (2018). *Professional development of geography with regard to summative assessment practices.* Enschede: Ipskamp Printing.

Bloom, B. S., Engelhart, M. D., Furst, E. J., Hill, W. H., & Krathwohl, D. R. (1956). Taxonomy of educational objectives: the classification of educational goals. Handbook 1: Cognitive domain, New York: David Mckay.

Bowman, M. A., Vongkulluksn, V. W., Jiang, Z., 8 –Xie, K (2020). Teachers' exposure to professional development and the quality, of their instructional technology use: The mediating role of teachers' value and ability beliefs. *Journal of Research on Technology in Education,* 1 – 17 doi: 10 -1080/15391523.2020.1830895.

Brown-Acquaye, H. A. (2001). Each is necessary and none is redundant: The need for science in developing countries. *Science Education,* 85 (1), 68 – 70.

Cheng, N., Tang, S., & Cheng, A. (2021). Praticalising theoretical knowledge in student teachers' professional learning in initial teacher education. *Teaching and Teacher Education* 28, 781 – 790.

Cheng, S. L., LU, L., Xte, K., & Vongkulluksn, V. W. (2020) understanding teacher technology integration from expectancy-value perspectives. *Teaching and Teacher Education*, 91, 103062. https://doi.org/10.1016/j.tate. 2020.103062

Darling-Hammond, L. (2010). Evaluating teacher effectiveness: How teacher performance assessments can measure and improve teaching. Washington DC,: Centre for American Progress.

Elmas, R., Rusek, M., Lindell, A., Nieminen, P., Kasapoglu, K., & Bilek, M. (2020). The intellectual demands of the intended chemistry curriculum in Czechia, Finland, and Turkey: a comparative analysis based on the revised Bloom's taxonomy. *Chemistry Education Research and Practice,* 21, 839 – 851.

Fitz Patrick, B. & Schulz, H. (2015). Do curriculum outcomes and assessment activities in science encourage higher order thinking? *Canadian Journal of Science, Mathematics and Technology Education,* 15(2), 136 – 154.

Freeman, S., Haak, D. & Wenderoth, M. P. (2011). Increased course structure improves performance in introductory biology. *CBE Life Science Education* 10, 175 – 186. doi: 10.1187/cbe.10-08-0105.

Guskey, T. R. (2002). Professional development and teacher diange. *Teachers and Teaching,* 8(3), 381 – 391

Hari, P., Warmelink, H., Valente, M. & Roth, C. (2018). Using the Revised Bloom's Taxonomy to analyse psychotherapeutic games. *International Journal of Computer Games Technology.* 1 – 9, 8784750.

Harlen, W., & James, M. (1997): Assessment and learning: Differences and relationships between formative and summative assessment. *Assessment in Education*, 4(3), 365 – 379.

Harr, N., Eichler, A. & Renki, A. (2014). Integrating pedagogical content knowledge and pedagogical/psychological knowledge in Mathematics. *Frontier in Psychology*, 5 (924), 1 – 10 doi:10.3389/fpsyg.2014.00924.

Hobbins, J. O., Murrant, C. L., Snook, L. A., Tishinsky, J. M. & Ritchie, K. L. (2020). Incorporating higher-order thinking and deep learning in a large, lecture-based, human physiology course: Can we do it? *Advances in Physiology Education*, 44, 670 – 678.

Hubers, M. D., Endedijik, M. D. & van Vean, K. (2020). Effective characteristics of professional development programmes for science and technology education. *Professional Development in Education*. 1 – 20. doi: 10.1080/19415257.2020.1752289

Kim, M. K., Xie, K., & Cheng, S. L. (2017). Building teacher competency for digital content evaluation, *Teaching and Teacher Education*, 66, 309 – 324. https://doi.org/10.1016/j.tale.2017.05.006.

Konig, J., Bremerich-Vos, A., Buchholtz, C. & Glustsch, N. (2020). General pedagogical knowledge, pedagogical adaptivity in written lesion plans, and instructional practice among preservice teachers. *Journal of Curriculum Studies,* 52(6) 800 – 822. doi: 10.1080/00220272.2020.1752804.

Lane, R. & Bourke, T. (2016). The inclusion of geography in TIMSS: Can consensus be reach? *International Research in Geographical and Environmental Education*, 26(2), 166 – 176.

Lee, Y., Kim, M. & Yoon, H. (2015), The intellectual demands of the intended primary science curriculum in Korea and Singapore: An analysis based on revisal Bloom's taxonomy *International Journal of Science Education,* 37(13), 2193 – 2213.

Marshall, K. (2012). Fine tuning teacher evaluation. *Educational Leadership.* 70(3), 50 – 53.

Oyo State Universal Basic Education Board (SUBEB) (2021, January). *School based training manual for public primary school teachers in Oyo State.* Government Press, Agodi: Ibadan.

Rice, D. (2012, July). Developing teacher/principal model evaluation systems. A paper delivered at Nebraska school administrator days. Kearney NE.

Schulz, H. W., & Fitzpatric, B. (2016). Teachers' understandings of critical and higher-order thinking and what this means for their teaching and assessments. *Alberta Journal of Educational Research*, 62(i), 61 – 86.

Simon, B. & Taylor, J. (2009). What is he value of course-specific learning goals? *Journal of College Science Teaching,* 53 – 57. Available from: http://www.cwsci.ubc.ca/SE/research/files/lifesci/simon Taylor Value of Course Specific LG. pdf (accessed June 2021).

Snowman, J. & Beihler, R. (2006). *Psychology applied to teaching*. Boston. Houghton Mifflin.

Stronge, J. H., Ward, T. J. & Grant, L. W. (2011). What makes good teachers good? A cross case analysis of the connection between teacher effectiveness and student achievement. *Journal of Teacher Education*, 6 2(4), 339 – 355.

Toy, B. Y. & Ok, A. (2012). Incorporating critical thinking the pedagogical content of a teacher education programme; does it make a difference? *European Journal of Teacher Education,* 35(i) 39 -56 doi: 10. 1080/02619768.2011.634902.

Tyler, R. W. (1949). *Basic principles of curriculum and instruction*. Chicago: University of Chicago Press.

Vanderhook, C A. (2020). The type of questions being promoted in a 10th Grade Social Studies textbook. Seton Hall University Dissertations and Theses (CETDs) 2730. htpps://scholarship.shu.edu/dissertations/2730.

Wei, B. (2020). The change in the intended Senior High School Chemistry Curriculum in China: focus on intellectual demands. *Chemistry Education Research and Practice*, 21, 14 – 23.

Wei, B., Ou, Y. (2018). A comparative analysis of junior high school science curriculum standards in Mainland China, Taiwan, Hong Kong and Macao: Based on revised Bloom's taxonomy. *International Journal of Science and Mathematics Education*, 17(8), 1459 – 1474.

Weisberg, D., Sexton, S., Mulherm, J., & Keeling, D. (2009). *The widget effect: Our national failure to acknowledge and act on difference in teacher effectiveness.* Retrieved from website: http://tntp.org/assets/documents/The WidgetEffect_2nd_ed.pdf.

Wijnen, F. van der Molen, J. W. & Voogt, J. (2021). Measurement primary school teachers' attitudes towards stimulating higher-order thinking (SHOT) in students: Development and Validations of the SHOT questionnaire. *Thinking Skills and Creativity*, 42, 100954.