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Educational Testing Techniques in Senior Secondary School Physics in Nigeria: Are We Ascertaining the Development of Requisite Behavioural Objectives?

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ABSTRACT

In order to estimate exam question demands and distributions in senior secondary school physics, this study was conducted. For the determination of the types of tasks involved, quantitative and qualitative research methods were combined (mixed method). Using Bloom's taxonomy of educational objectives, content analysis was carried out on questions from West African Examination (WAEC) and University of Cambridge International Examination. A perceptual Rating Scale (PRS) with a reliability coefficient of 0.89 was used to determine the readability indices of the questions. Detailed information on the subject matter was gathered through an in-depth interview of two students who sat for the two examinations in the year 2021. Analysis of the data obtained was conducted using inductive thematic analysis and descriptive statistics. Bloom's taxonomy revealed that most questions were related to the lower levels (remembering and understanding), but no or very few questions were related to the higher levels. These outcomes portend far-reaching implications for the overall goals of teaching physics. It was therefore recommended that besides scaling up the training for inspectorate officers in the Ministry of Education, it is highly imperative for critical stakeholders and examination bodies, in particular, to promote questions along higher-order cognitive levels.

Keywords: Bloom's Taxonomy, Higher-order cognitive skills, Physics Test Items.

INTRODUCTION

Educational testing remains the most plausible means of ascertaining students' scholastic attributes. There is growing attention among nations on issues relating to testing possibly due to international benchmarking (Kamens and Mcneely,2009). Baker (2008) described a cascade of influences of well-designed tests to include: evaluation of students' progress, assessing whether students are learning what was intended, promoting good study habit, increasing motivation for learning and provides feedback and corrective measures.

Examining bodies at national and international levels employed tests to make judgements and providing feedback and corrective measures. Despite stupendous emphasis dedicated to science teaching by doing, there is an over-domineering role of the paper and pencil approach to testing. It is doubtful whether this testing approach will measure a high degree of competence in scientific activities that involve a high order thinking process.

Aligning science teaching advances with science testing techniques represents a real challenge for the science education community. In today's science classroom, teachers are being trained in ways to be more effective at instructing students. Furthermore, students are encouraged to think critically and creatively, acquire scientific understanding, and understand the various points of view surrounding them. Science should be seen as a real and attainable goal by students beyond understanding concepts, processes, and the discipline's nature. Cervetti & Barber (2008) argue that conceptual understanding of scientific topics has little effect on students' actual decisions about real-world issues, despite historical tension between text-dominated and conceptually tailored testing techniques (Nisbet & Scheufell, 2009). If science education and development is to make a difference in the lives of teachers and students, it must be aware of changing policy and public awareness contexts. A way out of this daunting challenge possibly will be to reflect on the current practice in curricula development in educational testing techniques. A cursory look at some of the overarching objectives of the two examining bodies reflects this. Excerpts from their curricula provisions reveal the following:

The University of Cambridge International Examinations emphasized a curriculum structured such that students attain*:*

An understanding of theory and practice

Learning about the development and evolution of scientific theories and methods resulting from the collaboration of groups and individuals

The Nigerian Senior Secondary School Physics Curriculum was designed to*:*

Make sure society has a basic understanding of physics for it to function effectively

To prepare for the technological application of physics, acquire essential scientific skills and attitudes

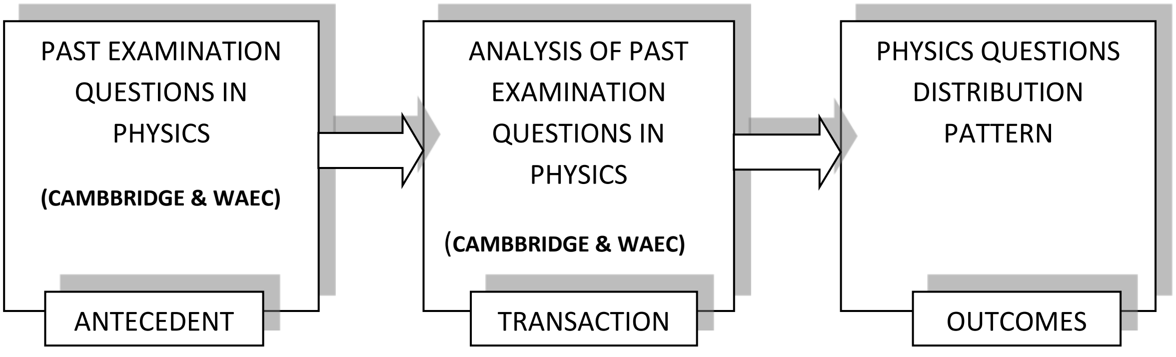
Enhance creativity by stimulating it (Amusa, 2021).

Students study in ways that reflect the assumptions they hold about their future tests, as evidenced by a growing body of research. When they expect a test that focuses on facts, they minimize details; when they expect a test that requires problem-solving or integrating information, they strive to understand and apply it. Developing and implementing assessment tools that meet the curriculum's goals or help students improve their higher-order skills should be the goal of education (Gal & Garfield, 1997). It implies that testing in physics should place much premium on higher-order cognitive skills, which will task students to acquire visual, spatial, and problem-solving skills and the ability to transfer knowledge to daily life experiences (Istiyono et al., 2020). By acquiring such skills, learners will be equipped with useful knowledge, reasoning abilities, skills, and values for success in the workplace and in their daily lives.

This study sought to identify the distribution and demand of physics examination questions in senior secondary school and extrapolate those transferable skills that make science relevant to everyday life of students (Amusa & Emmanuel, 2022). There was an attempt to compare questions from two examination bodies (WAEC and the University of Cambridge International Examination) in order to identify areas of strength and weaknesses of WAEC physics questions.

THEORETICAL FRAMEWORK

In this study, the Stake's countenance model (1967) was considered due to its ability to distinguish failure due to a lack of logical contingencies (theory failure) from failure due to incongruence between the program model and the actual behaviour of the program. Stake (1967) suggested three stages for evaluating educational programs: antecedents (previous evaluation conditions), transactions (during the implementation of the program), and results (the results of the program). Diagrammatic representation of these variables for this study is shown as



The study also employed Anderson and Krathwohl's (2001) modified version of Bloom's (1956) taxonomy to guide it. In the development of behavioral objectives, Bloom's (1956) taxonomy of educational objectives has been used as a guide. Education has three components: cognitive, affective, and psychomotor. Cognitive domains were the focus of this study since the affective domain is not assessed by examining bodies, and the psychomotor domain is largely higher-order cognitive. As identified by Bloom (1956) and cited by Akinboboye and Ayanwale (2021), there are six levels:

- Remembering that requires recognition of facts, principles, or processes.
- Understanding entails the acquisition of skills to explain or summarize.
- Applying requires the ability to make use of acquired knowledge in a new situation. It also involves the performance of some mathematical logarithms or manipulations.
- Analyzing, which requires the ability to break apart a whole or concept into components.
- Creating. is the ability to arrange and combine pieces, parts, or elements in such a way as to constitute a pattern or structure not present before.
- Evaluating involves qualitative and quantitative judgment about the extent to which materials and methods satisfy criteria laid down by students.

The publication of Bloom's taxonomy of educational objectives in 1956 led to numerous changes in our testing techniques, which influenced the evaluation of new knowledge by educators, students, and teachers. It was because of this that Anderson and Krathwohl (2001) revised Bloom's (1956). In addition, the revised version does not have a cumulative hierarchy like the original. Each stage is now considered a cognitive process. The knowledge is classified as factual knowledge (basic knowledge entails such verbs as remember, understand, classify, describe, discuss, explain, identify, locate, organize, select, translate), conceptual knowledge (knowledge of concepts, theories, models, and structures), procedural knowledge (methods of inquiry and algorithms), and metacognitive knowledge (Akinboboye & Ayanwale, 2021; Wilson, 2005). In fact, factual and conceptual knowledge deals with products, whereas procedural knowledge deals with steps to be followed. Also, included in procedural knowledge are criteria for when to use various procedures and an understanding of the different processes. Thus, This study examines the higher order thinking skills required to examine the prevalence and demand of physics questions. Additionally, the study measured the frequency with which higher-order skills are assigned to senior secondary physics students.

METHODOLOGY

An assessment of two examining bodies' physics exams was conducted using mixed methods research; the West African Examination Council (WAEC) and the University of Cambridge International Examination Council (UCIEC). While WAEC sets examination questions on senior secondary physics curriculum (ordinary level certificate examination) for students in Nigeria and other West African countries, UCIEC tests international students on the General Certificate physics curriculum. Quantitative data were gathered through content analysis of the questions using Bloom’s taxonomy as modified by Anderson (2005). In addition, reliability indices were developed to assess the extent to which the question items directly or indirectly relate science concepts to learners' everyday lives. A qualitative dimension was the open-ended (in-depth) interview conducted among graduates who sat for the examination within the years under investigation. The participants for the interview were selected convenience sampling technique from among the senior secondary school III graduates who took the two examinations in the past.

The procedure involved subjecting every question item of the examination to content analysis along the modified version of Bloom’s taxonomy of educational objectives (cognitive domain). For a start, examination questions in physics were carefully perused to determine years where students’ performance was abysmally poor, and such years were underscored for analysis. This was informed by the assumption that greater number of higher order tasks are likely to be present for such questions. A training session among researchers was organised to ensure that the tasks of analysis was achieved with near perfect competence. A training guide was prepared which provided clarifications on the task to be done. It consisted of two parts.

Part A explained the six types of Socratic questions: question for clarification, questions that probe assumptions, questions that probe reason or evidence, questions about viewpoints and perspectives, question that probe implications and consequences and questions about the question. These were further reduced to factual, convergent, divergent, evaluative and combinations. Concrete examples were provided in each of the cases. The second part considered levels of questioning using Modified version of Bloom's taxonomy (remembering, understanding, applying, analysing, evaluating and creating). Question cues (possible verbs) and examples were provided for the various levels as guide to researchers. The lead researcher anchored the training by providing vivid explanations on the content of the manual. All researchers were required to carry out analysis of ten items of a past question paper in physics (not used for the study). This involved placing a tally against appropriate level of Bloom's taxonomy. Total frequency and corresponding percentage frequency were computed for each of the levels. Results were compared and the process repeated individually and then collectively. A perfect outcome (common results) was achieved by the fourth attempt.

The Perceptual Rating Scale (PRS) was used to determine the readability indices of the questions. Baiyelo (2000) noted that teachers' perception quite ably represents students' perception of readability. Baiyelo (2000) tested this assumption from an interview with a small sample of teachers and a view of students. The congruence of these ratings obtained from a rank order correlation of 0.98 attests to the underlying assumption of high construct validity. The Readability index of the question items was determined through a self-constructed rating scale. PRS consisted of 3 distinct criteria: Deduction from diagrammatic illustrations, Illustrations relating to daily life experiences, Task involving numerical problems. These were arranged against two columns:' Yes' where the task is available and 'No' in a situation of the non-availability of a task. Researchers took a tally of Yes for each of the criteria. The rating was validated by subjecting it to peer review among three physics teachers. Readability was established, with some other questions not included in the study. There was no disparity in the scoring obtained among researchers. A split-half method was employed to establish reliability, and a value of 0.81 was obtained. Frequency count and percentage frequency were obtained and represented pictorially through a component bar- chart.

Two students who performed exceptionally on the two examinations were interviewed in-depth (open-ended). The sample size was determined by convenience sampling of two students from different universities with a secondary school science certificate. Their respective undergraduate degrees were in medicine and engineering from a Nigerian university. The aim was to determine the extent to which the demand for ordinary-level questions prepared them for education and daily life. The interview was recorded and transcribed.

RESULTS

Table 1 shows the preponderance of question items at lower level (remembering and understanding) throughout the years under consideration and cut across the two examining bodies. It reveals further that at least one-quarter of the examination question items (except WAEC 2003) dwell on applying. As the table indicates, there is a complete absence of question items (except 2006) and higher levels (analyzing, evaluating and creating) in WAEC while there are fewer representations of question items at higher levels for the Cambridge examination.

Figure 1 below reveals that the Cambridge examination rather than WAEC provided more questions that required students to deduce from diagram. However, Cambridge examination contained fewer problem-solving tasks than WAEC. However, the two examinations have comparable number of question items that relate physics concepts to the daily life experiences of learners.

An interview was conducted to inquire from students whether the testing techniques prepared them adequately to cope effectively with challenge posed in their chosen career while in school. The interview conducted was recorded and transcribed. Excerpts are presented:

Question

While in the high school, are you familiar with thought- provoking questions (involving critical analysis, deep reasoning and analytical task) in physics while in high school?

Engineering Student:

Not really. We are more exposed to solving numerical problems and questions that deals more with definition and explanation of scientific concepts.

Table 1
Frequency and percentage distribution of question items along with Bloom's taxonomy of educational objectives

Year	**Exam Body**	**Remembering**	**Understanding**	**Applying**	**Analysing**	**Evaluating**	**Creating**	**Total**
2003	WAEC	33 (36.6%)	39 (43.3%)	18 (20.0%)	-	-	-	90
	Cambridge	18 (19.1%)	23 (24.5%)	43 (45.8%)	05(5.0%)	03 (3.0%)	02 (2.0%)	94
2005	WAEC	34 (33.7%)	30 (29.7%)	37 (36.7%)	-	-	-	101
	Cambridge	12 (12.9%)	36 (38.7%)	38 (40.9%)	03(3.0%)	03 (3.0%)	01 (1.0%)	93
2006	WAEC	18 (35.2%)	19 (37.3%)	13 (25.5%)	- -	01 (2.0%)	- -	51
	Cambridge	10 (13.5%)	31 (41.9%)	27 (36.5%)	03 (4.1%)	02 (2.7%)	01 (1.4%)	74
2009	WAEC	21 (20.2%)	43 (41.3%)	40 38.5%)	-	-	-	104
	Cambridge	10 (11.9%)	35 (41.7%)	34 (40.5%)	02 (2.3%)	02 (2.3%)	01 (1.1%)	84
2013	WAEC	106 (30.4%)	131 (37.5%)	108(30.9%)	04 (1.1%)	- -	- -	349
	Cambridge	50 (14.5%)	125 (36.2%)	142(41.2%)	13 (3.7%)	10 (2.9%)	05 (1.4%)	345

Medical student:

In physics! Certainly not. This was experienced only in further mathematics

Response to this question accentuated the questioning pattern at ordinary level have not been geared towards solving spatial-visual problems. Question items can always be step up to the level of applying, analysing, evaluating and creating or down irrespective of the level of the learner. Doing this will only task students reasoning apparatus and inculcate appropriate scientific attitude. For instance, engineering or medicine requires a critical analysis, deep reasoning and analytical mind. A solid foundation could be laid where the testing technique is thought- provoking.

Question

Has your ordinary level physics examination prepared you adequately to cope effectively with the pattern of examination pattern in your degree programme?

Engineering student:

The orientation provided by physics examination at the ordinary level dwelled on regurgitation of acquired knowledge and not the application of knowledge often. However, at the university level, you engage yourself in serious thinking and tasking your brain. The two examinations are of the different ball game

Medical student:

No! You indeed need the knowledge and understanding of concepts at an ordinary level to do well in both examinations. However, the gap in demand for testing between both examinations is very wide.

Response by students further cast aspersion on the present testing technique. Whereas the rigour involved in the two examination cannot be the same. However, the ordinary level should provide students with appropriate scaffolding to ensure smooth transition.

Question

What makes the difference in the pattern of questioning between your ordinary level and university degree examinations?

Engineering student

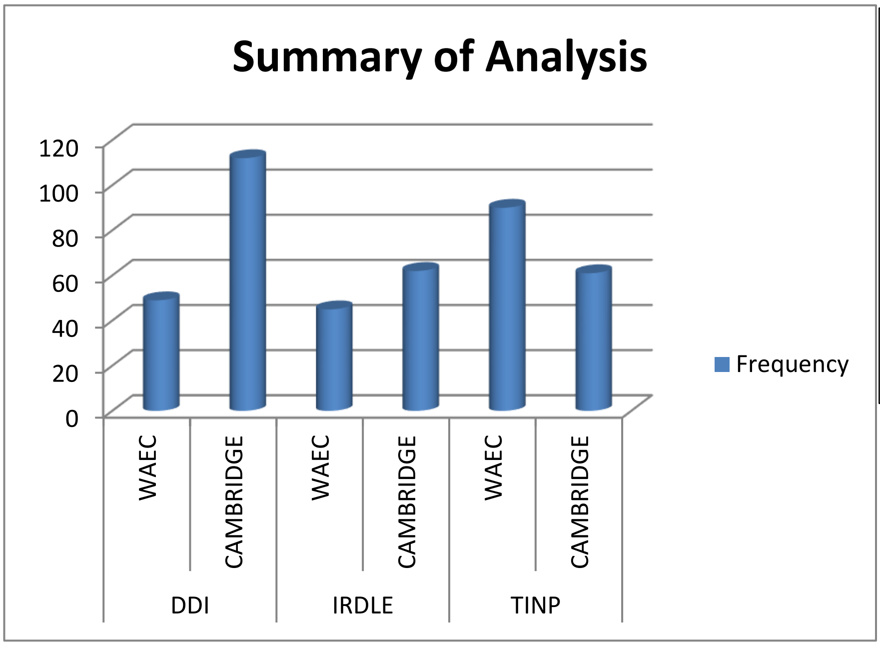
Ordinary level physics questions are less tasking and involve your ability to analyse data and substitute and simplify. For the degree programme, this is not so. It is more tasking and requires your ability to visualise, engage in imagination and concretize, all these will depend on your competence to think critically and analytically.

Medical student

There are differences between two examinations from my own perspectives. It is often difficult to maintain the same high score in your degree programme. This is because you require great analytical skills not exposed to at an ordinary level.

The response above implies that where there is congruence in the testing technique for ordinary and degree program, students at the degree level may achieve better than we are witnessing.

Figure 1: Showing component bar-chart on the readability of examination questions in physics.



KEY:

DDI: Deduction from diagrammatic Illustration

IRDLE: Item Relating to Daily Life Experiences

TINP: Tasks Involving Numerical Problems.

DISCUSSION OF FINDINGS

The finding of this study revealed the preponderance of question items at lower levels (knowledge and comprehension) of Bloom's (1956) taxonomy of educational objectives in the cognitive domain. This agrees with earlier finding of Kellaghan (2004) but contradicts the nature and effective way of learning of physics as a subject. Physics entails that students analyse events conceptually, think creatively and have the ability to solve problems. Present observation only promotes memorisation and regurgitation of facts, concepts and principles. Using the classification of Wilson (2006) connotes factual and conceptual knowledge.

The study revealed a fair representation of question items and the application level. This is a welcome development as students will comprehend and interpret physics and explain the situation they face in daily life. Researchers

(Kelleghan,2004; Ayvaci & Turkdogan, 2010) think that opinion that application questions should dominate the higher-order skills with a corresponding reduction in questions requiring retention skills. This was observed in the Cambridge examination (figure 1) where diagrammatic illustrations were employed to relate physics to daily life experiences. Students were tasked to interpret diagrams concerning specific physics concepts.

Findings further revealed (table1) the lack (Cambridge) or complete absence (WAEC) of questions along with the higher level. This confirmed an earlier finding by Kellaghan (2004) and supported the general view that the spread and demand for public examinations in physics have not matched the curricula prescriptions. This may be attributed to the preponderance in physics classroom of the lecture method (Owolabi, 2004) where teacher talks and students listen. Intellectual transaction in such classrooms promote recall of facts and passive listening and are usually devoid of activities. Invariably teachers who engaged in the lecture method have no plausible alternative but to adopt the same way (construct questions that require recall or memorizing ability) in testing to avoid massive failure of students in physics. The use of higher order skills in promoting technological advancement are well documented in the literature. Students who have such skills well developed in them are usually creative, critically minded and efficient problem solvers. They are also capable of visualising problem and are imaginative thinkers. Effective questioning should raise issues which trigger students to think and stimulate mental activities. According to Kocakaya and Goren (2010), quality of question asked in physics usually contributes to the creativeness of students and their critical mind. At the same time, the Cambridge questions have more questions tasking students on deductions from graphical illustrations triggering students reasoning and higher order cognitive skills. The WAEC questions dwelled less on this, hence the low representation of questions along this critical area.

The findings of this study have revealed that a lacuna exists between the antecedent (curricula objectives), the transaction (past examination questions), and the outcome (past examination questions distribution pattern). It implied that the overall goal of physics teaching is to prepare students for useful living and the applicability of physics to real-life situations. The testing procedure has not been fully satisfied. This portends a far-reaching implication for the teacher, policymakers, research in science teaching, and examination bodies. There is always a reluctance to change in light of any recent innovations. It becomes imperative to step up efforts towards supervision of teaching in physics.

Inspectorate officers should be retrained, as well as teachers that match the expectations on the field. There is an urgent need for a resurgence by the examination bodies in this direction. They should work in tandem with the practitioners' teachers who are to keep abreast of happenings in the classroom. More question items are required at a higher-order cognitive level than is presently constituted. Science education research beam light should be focused incessantly on what happens in physics classrooms. This will put teachers on their toes and provide valuable information and feedback to all stakeholders. There is a need to make physics teaching more activity based and familiarize students with thought-provoking, analytical, and visualizing tasks. These will develop in the learner higher-order cognitive skills (applying, analyzing, evaluating, and creating) needed as a springboard and bedrock for future career challenges in the sciences. Physics classrooms should be dominated by activity and participatory teaching. Physics should be related to the daily life experiences of students. A reflection of all these in educational testing is highly essential. The teaching of physics in these ways will bring out real mental skills, develop students' ability to think well, be intuitive and creative and use their cognitive skills when faced with problem-solving tasks and critical analysis. By providing students with appropriate education enables them to solve higher-order physics problems and enhances their ability to think critically. The present findings have implications for teacher classroom practice, teacher development, assessment practices, and curriculum renewal.

SUGGESTION FOR FURTHER STUDIES

It is desirable to extend our search light on higher-order objectives through documentary analysis of practice exercises in physics textbooks and curriculum evaluation strategies.

CONCLUSION

This study employed the stakes countenance model to explore the spread of question items in physics and the modified version of Bloom's (1956) taxonomy of educational objectives. Findings revealed that the current practice had created a huge gap in the educational testing procedure. There is a predominance of low cognitive skills questioning at the instance of higher cognitive skills. Hence a mismatch between policy expectations and reality.

REFERENCES

Aguiar, O. G., Martimer, E., & Scott, P. (2000). Learning from and responding to students' questions: The authoritative and dialogic tension. *Journal of Research in Science Teaching*, 47(2), 174-193.

Akinboboye, J. T., & Ayanwale, M.A. (2021). Bloom Taxonomy Usage and Psychometric Analysis of Classroom Teacher Made Test. *African Multidisciplinary Journal of Development*, 10(2), 2021. https://amjd.kiu.ac.ug

Amusa, J. O. & Emmanuel S. E. (2022). Investigating Students' Awareness of Relevance of Physics Concepts on Domestic Experiences in Niger State, Nigeria. Noun Journal of Education. 8 (267 – 281).

Amusa, J. O. (2020). Appraisal of the physics education programme in the National Open University of Nigeria. *Technical University of Varna Annual Journal*, 4(1), 1-12 https://doi.org/10.29114/ajtuv.vol4.iss1.158

Ayvaci H. S., & Tukdogan, M. (2010). Analysing science and technology courses examination questions according to revised Bloom's taxonomy. *Turkish Science Education*, 7(1), 17-31

Baker, M (2008). Survey research and the public understanding of Science. In M. Bucchi & B *Trench (Eds.), Handbook of Public Communication on Science and Technology* (pp.111-130). London: Routledge.

Baiyelo, T. D. (2000). An evaluation of the adequacy of physics textbooks used in Lagos state senior secondary schools, *Issues in Education Journal*, 1(1), 1-20.

Bessell, A. G., Burke, M. C., Plaza, M. P., Lee, O., & Schumm, J. S. (2010). The educational reform rating rubric: Example of a new tool for evaluating complex school reform initiatives. *Field Methods*, 20(3), 283-295.

Bloom's, B.S. (1956). *Taxonomy of Educational Objectives Handbook 1: The cognitive domain.* New York: David Mckey.

Cervetti, G. N., & Barber, J. (2008). Texts in hands-on science. In E. H. Hiebert& M. Sailors (Eds.), *Finding the Right Texts: What Works for Beginning and Struggling Readers* (pp.89-108). New York: Guilford.

Gal, I., & Garfield, J. (1997). Curricular goals and assessment challenges in statistics education. *The assessment challenge in statistics education*, 1-13.

Istiyono, E., Dwandaru, W. S. B., Setiawan, R., & Megawati, I. (2020). Developing of Computerized Adaptive Testing to Measure Physics Higher Order Thinking Skills of Senior High School Students and Its Feasibility of Use. *European Journal of Educational Research*, *9*(1), 91-101.

Kamens, A. P., & Mcneely, H.E., (2009). Using science simulations to support powerful formative assessments of complex science learning. *Journal of Research on Educational Effectiveness*, 3(2), 157-198.

Kellaghan, T. (2004). Public examinations, national and international assessment and educational policy, *Assessment in Education*, 8, 81-102.

Kocakaya, S. & Goran, S. (2010). Analysis of Turkish high school physics. Examination questions according to Bloom's taxonomy, *Asian –Pacific Forum in Science Learning and Teaching*, 11(1),1-12.

Nisbet, M. C., & Scheufele, D.A. (2009). What's next for science communication? Promising directors and lingering distractions, *American Journal of Botany*, 96(10), 1767-1778.

Owolabi, T. (2004). A diagnosis of Students' Difficulties in Physics, *Educational Perspectives*, 7 (2), 15-20.

Stakes, R. E. (1967). The countenance of educational evaluation. *Teacher's College Record*, 68, 523-540.