# An analysis of cognitive competency of learning outcomes of Biology Curriculum and its comparison with textbook and Question Papers (in perspective of Pakistan)

**Sadia Shahbaz,[*] Dr.Muhammad Waheed[**]**

*Department of educational training, The Islamia university of Bahawalpur

** Department of Educational Research & Evaluation, The Islamia University of Bahawalpur

**Abstract:** This study aims to analyze cognitive competency learning outcomes of curriculum of biology its frequency mapping with same level of text book. The purpose is to know at what cognitive level curriculum and text book are existing in system, and what level of cognitive skills these both master documents are expecting to inculcate in learner. This comparison also provided an existence of higher order and lower order thinking skills in curriculum and text book. This analysis was done by using qualitive research method approach and technique used to perform it is descriptive analysis of documents (curriculum & text book and examination). For obtaining more concise results, following two instruments were used:

1) Curriculum Textbook Alignment Framework

2) Curriculum Textbook Alignment Rubric (based on competency levels of bloom's revised taxonomy).Findings of the study depicts, that there is considerable difference of cognitive competency levels in learning outcomes of biology curriculum and textbook. These are evaluated on the basis of cognitive skills mentioned in curriculum by number of lectures and with a new dimension introduced by researcher to do categorical analysis of all learning outcomes on cognitive competency basis. The results showed, Curriculum has more focus to inculcate understanding ability while text book focuses on remembering ability, irrespective to the conceptual need of other cognitive skills of secondary education learners.

The inferences of above findings are, our teaching system is more inclined to promote lower order competency skills (LOCS) and less consideration of higher order competency skills (HOCS) improvement. This trend is further disseminated in teaching process to examination system. This is the reason our examination is mostly based on memorization ability evaluation and other cognitive levels are badly ignored. Textbook being master document in teaching system needs revision in the light of curriculum's guidance and expectations. This study recommends, adoption of higher order cognitive skills mentioned in curriculum should be practically applied through text book into teaching system, this is the only way to improve students' knowledge and to get good results. Most importantly teacher should be trained on it through customized training process in order to play effective role for the improvement of higher order thinking skills of secondary level students.

Index Terms: Cognitive competency skills, curriculum text book alignment, LOCS,HOCS, learning outcomes.

## I. INTRODUCTION

Cognitive learning is a type of learning which focuses on most effective use of human brain. In order to understand this, first we need to know the meaning of cognition. It is referred as "to gain knowledge and understanding through experiences and thought process". When we make it part of learning habit it becomes continuous life long learning. These learning habits not only helps someone to be a good learner and also a team leader and motivational speaker.

"Curriculum lies at the heart of any educational enterprise and it is the plan of action through which a nation transmits its values and philosophy of life to its young generations" (Punjab Curriculum and Textbook Board [PCTB], 2019). Curriculum delineates goals and competencies intended to inculcate in students to compete with other cohorts globally. Carroll, J.B. (2003) used cognitive abilities mapping as graphical representation of knowledge. Bloom's taxonomy (Bloom, 1984) is the most versatile and well- established model for analyzing and assessing the cognitive depth of students' learning and their ability to perform specified tasks envisioned in a curriculum.

Curriculum of Secondary School level in Pakistan is the core document to prepare instructional material in the form of textbook and have baseline of Bloom's taxonomy in its expected learning outcomes. Expected outcomes of curriculum are translated through textbook and evaluated through examination. Therefore, assessment is indispensable constituent to assess the progress of learning during teaching - learning process and at the end of specific period of study which is generally based upon the principles of Bloom's taxonomy (Krathwohl, 2002). Six levels of cognitive abilities are divided into low order thinking skills (first three levels) and next three levels as higher order thinking skills. In any academic program, a substantial portion of curriculum is normally taught to cater knowledge, comprehension, and application (first three levels of Bloom's taxonomy generally referred as lower-order thinking skills – LOTS (Roblyer et al., 1988) while other three levels are analysis, synthesis and evaluation are higher order thinking skills – HOT (Saido et al., 2018). Under the revised blooms taxonomy these three higher levels are analyzing, evaluating and creating. Curriculum at secondary level has adopted revised level of taxonomy to illustrate learning outcomes.

The syllabus of biology at secondary school level has variety of themes and problems related to life around us and insides of living systems. It ranges from cellular objects to diversity, genetic continuity, and the evolution of living things. "The complexity of these objects and problems enable biology to be very appropriate as materials for students to improve their thinking skills" (Mazzocchi, 2008). There is strong empirical evidence that the human mind is hierarchically organized, involving domain-specific and domain-general mental processes. Students' cognitive abilities can be improved by integrating the representation level in the text contained in the textbooks. Curriculum's effectiveness can be improved through problem solving, self-assessment and self-reflection (Kaur, 2018). The improvement of students' creativity in science requires that the students may improve their higher order thinking skills specially the synthesis and evaluation skills (Saido et al., 2018). So the school intends to improve the academic performance of their students may improve the cognitive skills among students (Finn et al., 2014).

Learning outcomes can be satisfied only if the research study covers measuring of cognitive aspects also (Duque & Weeks, 2010). Textbook of biology enlisted learning outcomes based on the concepts of curriculum. These

learning outcomes are delivered through teaching and learning process and evaluated through assessment process either formative or summative at school level for the preparation of terminal public examination. Ideally the attainment of learning outcomes is a cyclic process which starts from learning objectives defined in curriculum (CLOs) and linked with Student Learning Objectives (SLOs) of textbook. Outcomes of SLOs are evaluated through examination. Interpretation of results will reflect the extant of achievement of CLOs of curriculum. `

Punjab Curriculum and Textbook Board (PCTB) has responsibility of curriculum and text book preparation and also updating these documents. Curriculum of biology for class ix-x- is the focus of this study. It was revised in 2019 so the textbooks were also revised accordingly. The curriculum mainly focuses on three basic levels (knowledge, comprehension, and application) of cognitive domain. The entire academic workflow of students revolves around this basic document of curriculum, i.e., textbook. Public examination system and performance of students depends upon on these two master documents. There is a great need to review the impact of cognitive learning skills of curriculum and textbook and to monitor their impact on examination system. In a parallel level study of curriculum analysis by EFE, H. A., & Rıfat, E. F. E. (2019), it is concluded that the learning outcomes at the level of procedural and metacognitive knowledge be added to the current biology curriculum. Bhatti, A. J., Khurshid, K., & Ahmad, G. (2017) found that content in the biology -X text book was not aligned to a desired level. This misalignment was not same for all the categories of cognitive demand. While Bhatti, A. J., Jumani, N. B., & Bilal, M. (2015) observed that text book provided more content of knowledge level category of cognitive level while less content of comprehension and other higher level cognitive categories.

**II-Identify Research and Collect Idea**

Curriculum of Biology is main focus of this research, it is analyzed that curriculum of biology have 11 chapters which can be distributed into 04 sections as nature of material. section 01 is about General introduction of biology including chapter 01, focused on introduction, aims, objectives and general considerations of curriculum developers behind the development of curriculum. Chapter 02 is about transition of scheme of study into curriculum, textbook and dissemination into knowledge and skills. Chapter 03 is about standards and benchmarks and key learning areas for grades ix-xii, while Section 02 consisted on chapters 4,5,6,7 and have detailed explanation about expected learning outcomes for biology students. Section 03 has Chapter 08 and provides guidance about teaching strategies to meet the desired outcomes of curriculum, enquiry based teaching and strategies for learning of science are highlighted for the class teachers of biology. Section 04 have Chapter 09, is about Assessment and Evaluation process, various assessment techniques and its application time frame of teachers explained, many action verbs with their meanings given for the understanding of teachers. Sample pattern for paper setting for class ix is also given along with a model paper. Chapter 10 has focus on guidelines for developing teaching and learning resources for grades ix-xii. Following are main focus points of work:

i. To figure out and compare the aims, objectives and learning outcomes of the curriculum and its representation in textbook of Biology at SSC level.
ii. To determine frequency of learning outcomes alignment between curriculum and text book.
iii. To have comparison of lecture based and competency based outcomes of curriculum at secondary level and its mapping with biology text book.
iv. Detailed cognitive analysis of question papers of final examination at secondary level biology.

**Data Collection:** Qualitative research method with content analysis technique applied for the analysis of curriculum and text book. Curriculum of ix and x available in a single manuscript and analysed separately. Text books of biology for class ix-x revised in 2019 is analysed.

Two tools were used for data collection from above mentioned documents:

i. Curriculum-Textbook alignment framework (C-TAF) comprised of three sections; curriculum organization, Chapter analysis and Descriptive analysis.
ii. Curriculum-Textbook alignment rubric, it analyzed the alignment within competencies, benchmarks, standards and Student Learning Outcomes of National Curriculum.

By using Curriculum-Text book Alignment Framework complete manuscript of curriculum divided into five sections and data collected from each section recorded in a excel file based on number of sections and chapters of curriculum. Same procedure was adopted for text book for analysis of sections, chapters and content. Results were recorded in excel file for further analysis.

Second tool for data collection is curriculum text book alignment rubric, which is developed by using bloom's five competency levels and all learning outcomes of curriculum and text book analysed by using rubric levels.

Third tool of data collection is past five years question papers of biology, all questions listed including multiple choice and detailed response parts of question papers.

Data Analysis:

Learning outcomes of curriculum analysed on two parameters, one is to list down cognitive skills mentioned in curriculum and analysed on the basis of number of lectures required to deliver these learning outcome, it is a simple numerical calculation of cognitive abilities mentioned collectively against each chapter and no representation of cognitive competency of each learning outcome at individual level. Nature of research demands there is need to know each learning outcome categorically to have idea what type of knowledge is required in text book. Competency based analysis is the only effective tool to know the spirit of each learning outcome.

Competency based analysis of learning Outcomes: A new dimension was proposed by researcher which was not mentioned in curriculum is to analyze each learning outcome of curriculum on 05 competency levels of bloom's taxonomy. For this purpose, learning outcomes of class ix and x analysed separately as item wise and their results were recorded in a table. It showed, number of times a competency is found in a chapter reciprocally will be its representation in curriculum. Curriculum is also analysed on number of lectures basis and also some additional parameters of cognitive competency basis by using Bloom's revised classification.

Curriculum Text Book Alignment Rubic based on Blooms taxonomic classification by using five levels of competency used for the analysis of learning outcomes, these levels are categorized as per following:

Remembering= 0, understanding =1, application = 2, analysis =3 evaluation = 4 and create = 5. These rubrics used for the quantification of learning skills of learning outcomes of curriculum and text book.

III WRITE DOWN YOUR STUDIES AND FINDINGS

Aims, objectives, learning outcomes of curriculum extracted and evaluated on the basis of cognitive skills required to meet Curriculum Learning Outcomes and its numerical values analyzed on the basis of no of lectures required for that learning outcome and competency score of cognitive skill: Biology Subject Specific Aims of biology curriculum are following:

i. A scientific understanding of the living world
ii. Mental and motor abilities appropriate to the acquisition and use of biological understanding
iii. An appreciation of the products and influences of science and technology, balanced by a concern for their wise application
iv. An understanding of the nature and limitations of scientific activity
v. An ability to apply biological understanding to appropriate problems (including those of everyday life) and to approach those problems in rational ways
vi. Respect for evidence, rationality and intellectual honesty
vii. Capacities to express themselves coherently and logically, both orally and in writing, and to use appropriately modes of communication characteristic of scientific work and an ability to work effectively with others.

Cognitive Analysis of Aims of curriculum have focus on cognitive abilities as per bloom's taxonomic levels. The levels which desired through aims are understanding, analysis, application, evaluation and create level cognitive abilities as per Blooms's taxonomy levels.

Subject Specific Objectives Mentioned in Curriculum are as follows:

i. Students should understand the scientific concepts inherent in the theme for each chapter to be covered well enough to be able to state, exemplify and interpret the concept of biology use of fundamental terms and classifications related to the concepts and explain or interpret, scientific evidence in support of the concepts.

ii.. Students should show some ability to: formulate questions that can be investigated by gathering first or second-hand data

i. find relevant published background information
ii. formulate hypotheses and make predictions from them
iii. plan an investigation and carry out the planned procedures
iv. use the motor skills required to carry out investigations
v. observe phenomena, and describe, measure and record these as data
vi. classify, collate and display data
vii. interpret and construct visual representations of phenomena and relationships (diagrams, graphs, flow charts, physical models etc.)
viii. analyze data and draw conclusions • evaluate investigative procedures and the

conclusions drawn from investigations.

For each of the facets of scientific activity selected for study, students should:

ix. describe and exemplify it, use appropriately any fundamental terms and classifications related to it

x. recognize that the problem-solving nature of science has limitations

xi. acknowledge that people engaged in science, a particularly human enterprise, have the characteristics of people in general.

xii. recognize that the technology resulting from scientific activity influences the quality of lifestyle and economic development through or by improvements in medical/health care, nutrition, agricultural techniques

xiii. understand that these influences may be the result of unforeseen consequences, rapid exploitation or rapid cultural change

xiv. realize that advances in technology require judicious application.

Ability to apply Understanding to Problems: Students should:

xv. recognize that biological knowledge and scientific approaches have relevance to many situations in everyday life

xvi. recognize when biological knowledge is relevant to a problem

xvii. recognize when a scientific approach is relevant to a problem

xviii. select and apply appropriate biological knowledge and skills to clarify and help produce solutions to problems, especially the personal and social problems of everyday life to which such knowledge and skills can apply

xix. use thoughtful, rational strategies for decision-making in those everyday situations to which both biological knowledge and value positions are relevant.

Students should participate in group work in such a way that he or she:

xx. shares the responsibility for achieving a group task

shows concern for the fullest possible participation of each group member

Cognitive Analysis of curriculum's Objectives**:** Cognitive abilities of bloom's taxonomy including remembering, understanding, application, analysis up to create levels has been focused in subject specific objectives of biology curriculum.

Learning outcomes of curriculum and how to focus them for curriculum analysis:

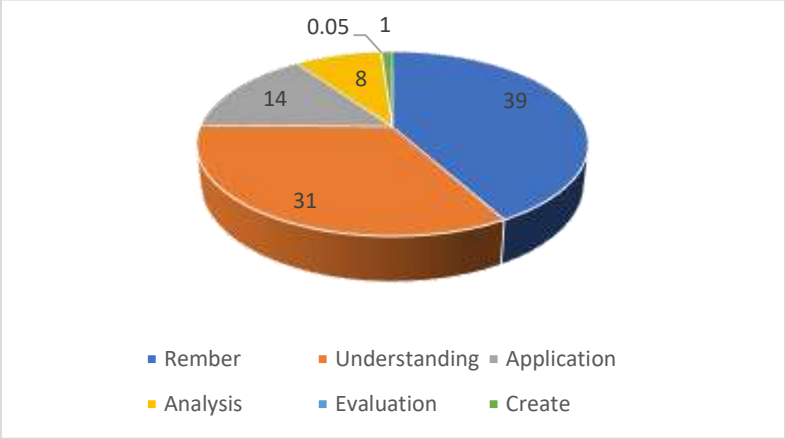
Learning Outcomes is a statement of knowledge, skill and ability which we want to inculcate in individuals and text book is the source to translate desired expectations of curriculum into meaningful knowledge. Curriculum provides general guidance of skills and abilities and text book provide platform for inducing these required skills.

curriculum of grade ix and x reviewed and analysed in detail by researcher as chapter wise also section wise, following is the methodology adopted for it and also outcomes of this analysis.

There were 119 Learning outcomes of curriculum of class ix biology have been evaluated on the basis of content analysis technique by using clues of action verbs provided in it. Numerically these were scored on competency basis and results obtained are tabulated in the following table and also represented in a graph. The following table gives a comparison of learning outcomes on the basis of number of lectures versus competency score.

For this purpose of analysis, content of questions asked at the end of each unit analysed through content analysis technique. Competency levels of blooms taxonomy applied for the classification of student's learning outcomes. Results obtained are following:

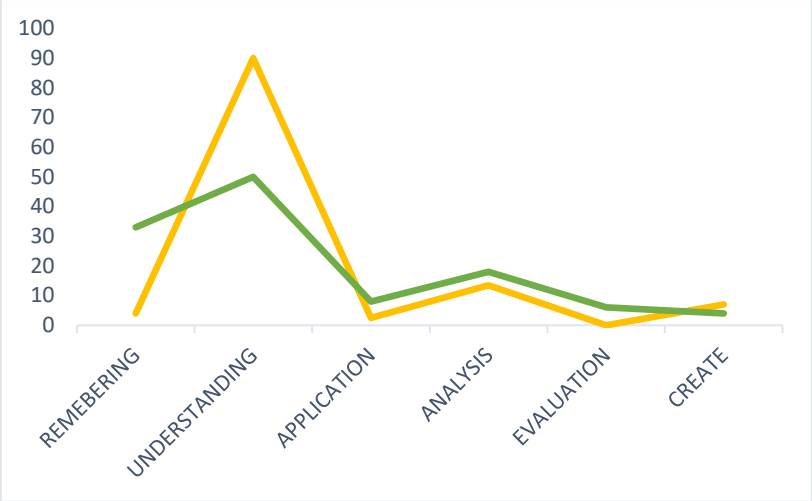
Cognitive Analysis of Biology Textbook




Results showed, remembering skill is dominating on all five skills and focused in more parentage**.** When we compare these results with curriculum this have less focus than understanding skill which is in more focus of curriculum**.**

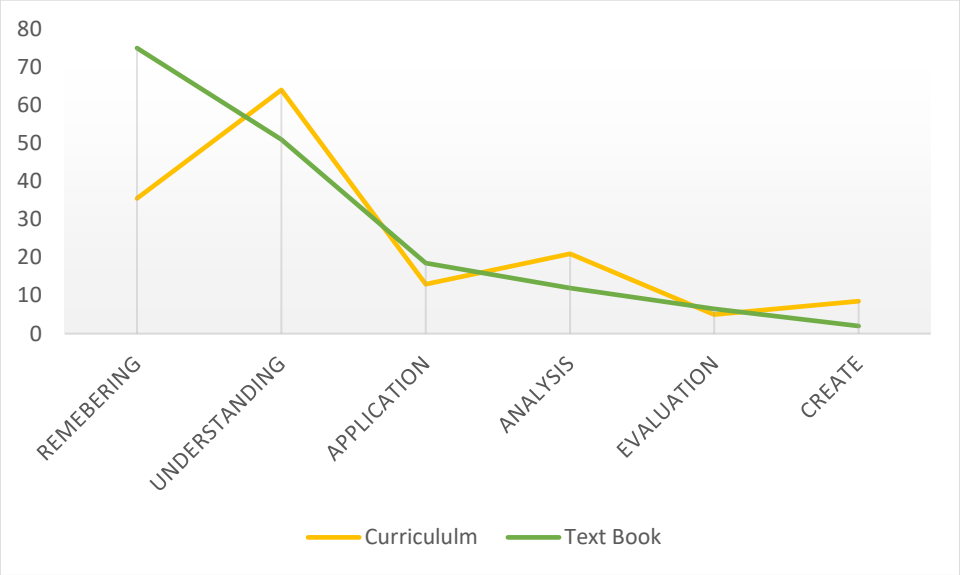
This all scenario present a picture that actually the comparison is between frequency of learning outcomes of text book and curriculum, either evaluated on cognitive competency basis or on the basis of number of lectures required to transfer desired cognitive skill.

Cognitive analysis of Biology curriculum



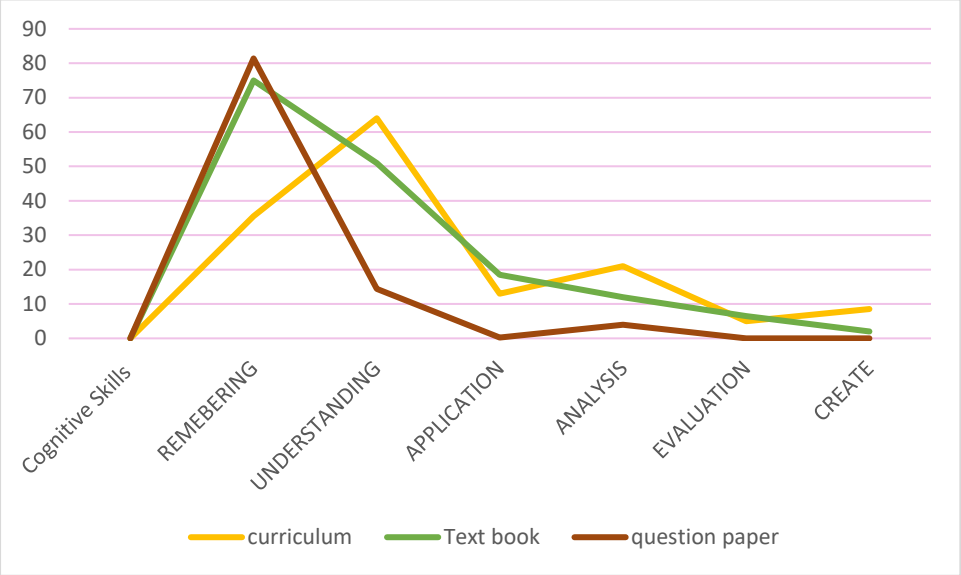

Results from above graph have showed a gradual trend of increase and decrease of cognitive skills either on lectures proposed to deliver by curriculum to induce cognitive competency through text book.

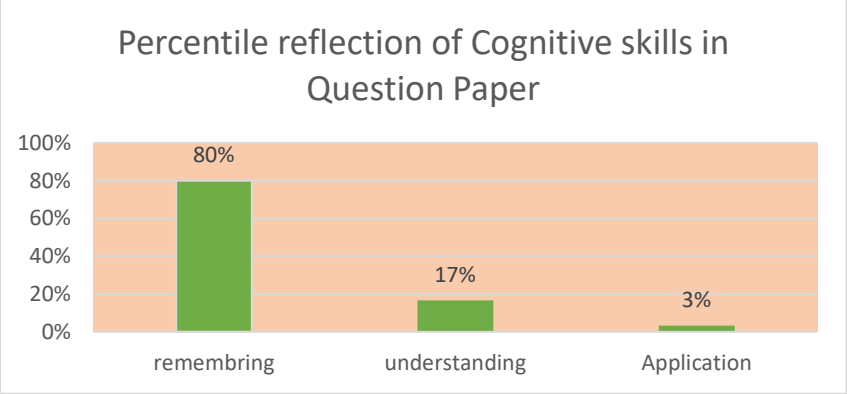
Cognitive comparison of curriculum with text book




Results of above comparison depicts an increased level of cognitive abilities from lower order thinking skills of curriculum to text book and this trend is more clearly visible in text book cognitive levels, remembering skill is more inclined to increase in text book and at understanding skill is at better levels in curriculum while all four remaining cognitive skills are at meager in text book while there text book score is better. This all proved that curriculum have better representation of cognitive while text book have no reflection of all these skills therefore, this trend is trialing down in examination system also.

Cognitive Comparison of Curriculum, Text Book and 05 years Question Paper




Results showed, there is gradual increase of remembering skill from curriculum to question paper level and this trend is declined at understanding level while other levels of cognition including Application, analysis, evaluation and create have showed a gradual trend of decrease of cognitive abilities from curriculum to text book and also in question papers.

Conclusion:

In the preamble of research work it was planned that through this research work a comparison will be evoked to evaluate cognitive competency analysis of curriculum and text book and this will be compared with question paper previous years. According to the study's findings, there are significant differences between the frequency of competency levels and learning outcomes of biology curriculum and textbook. Based on the cognitive skills mentioned in the curriculum, learning outcomes have been evaluated through a number of lectures, and a new dimension introduced by the researcher is the categorical analysis of all learning outcomes based on cognitive competency. As a result of the above findings, it is apparent that in Pakistan teaching system places a greater emphasis on promoting lower order competence skills than on improving higher order competencies. This trend is further disseminated in teaching process to examination system. This is why our examinations are mainly based on memorization ability evaluation and other cognitive levels are poorly ignored.

ACKNOWLDGEMENTS: Researcher have heartfelt gratitude for all the individuals and institutes remain involve for refining and supporting of work without their support this work cannot be possible. A very appreciation for

the contribution of secondary education board Bahawalpur examination team for their valuable support and provision of access of documents for in-depth analysis of examination system and a very remarkable input of paper setters and marking team members from 09 boards of Punjab. No doubt a sincere appreciation for Dr.Muhammad Waheed (my supervisor of research work) for refining of work and also keep me on track as per targets of research.

Future Prospective**:** This research work explored cognitive skills of curriculum and text book but it can be effective when applied in teaching system and adopted by teacher. Future researcher can devise how to adopt cognitive demands of curriculum and text book in practical circumstances.

Novelty of Research**:** Although a lot of work done in curriculum analysis but area of cognitive comparison of curriculum with text book and to see their relationship with examination system is new dimension and no significant work done before.

REFRENCES

[1] Ahmed, N., Anwar, M. A., Wajahat, U., Edriss, A., & Abdurahen, M. (2014). Bloom's taxonomy based proportionate curriculum development model. Journal of education and practice, 5(26), 12-17.

[2] Bhatti, A. J., Jumani, N. B., & Bilal, M. (2015). Analysis of Alignment between Curriculum and Biology Textbook at Secondary Level in Punjab. Pakistan Journal of Social Sciences (PJSS), 35(1)

[3] Bhatti, A. J., Khurshid, K., & Ahmad, G. (2017). Curriculum Alignment: An Analysis of the Textbook Content. *Pakistan Journal of social Sciences (PJSS)*, *37*(1).

[4] Carroll, J. B. (2003). The higher-stratum structure of cognitive abilities. *The Scientific Study of General Intelligence*, 5-21. https://doi.org/10.1016/b978-008043793-4/50036-2

[5] Duque, L. C., & Weeks, J. R. (2010). Towards a model and methodology for assessing student learning outcomes and satisfaction. *Quality Assurance in Education*, *18*(2), 84-105. https://doi.org/10.1108/09684881011035321

[6] Finn, A. S., Kraft, M. A., West, M. R., Leonard, J. A., Bish, C. E., Martin, R. E., Sheridan, M. A., Gabrieli, C. F., & Gabrieli, J. D. (2014). Cognitive skills, student achievement tests, and schools. *Psychological Science*, *25*(3), 736-744. https://doi.org/10.1177/0956797613516008

[7] EFE, H. A., & Rıfat, E. F. E. (2019). Comparison of the Learning Outcomes in 12th Grade Biology Curriculum According to the Revised Bloom Taxonomy: 2013, 2017 and 2018 Curriculums. *Journal of Computer and Education Research*, *7*(14), 464-479.

[8] Kaur, R. (2018). A critical analysis of question papers in different school subjects at class ix level. International Journal of Research in Social Sciences, 8(3), 868-880. (n.d.).

[9] Krathwohl, D. R. (2002). A revision of bloom's taxonomy: An overview. *Theory Into Practice*, *41*(4), 212-218. https://doi.org/10.1207/s15430421tip4104_2

[10] Mazzocchi, F. (2008). Complexity in biology. *EMBO reports*, *9*(1), 10-14. https://doi.org/10.1038/sj.embor.7401147

[11] Roblyer, M. D., Castine, W., & King, F. J. (1988). *Assessing the impact of computer-based instruction: A review of recent research*. CRC Press.

[12] Saido, G., Siraj, S., DeWitt, D., & Al-Amedy, O. S. (2018). Development of an instructional model for higher order thinking in science among secondary school students: A fuzzy Delphi approach. *International Journal of Science Education*, *40*(8), 847-866. https://doi.org/10.1080/09500693.2018.1452307

First Author

*Sadia Shahbaz, Ph.D. Scholar Department of Educational Training, The Islamia University Bahawalpur.

Second Author

** Dr.Muhammad Waheed, Assistant Professor Educational Research & Measurement Department, The Islamia University Bahawalpur