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Original Research Article

Emphasizing the Importance of Outcome-Based Assessment Question Bank - Zoology: Course - Biosystematics Using Bloom's Taxonomy Framework

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Abstract

This study emphasizes the importance of creating an outcome-based question bank using Bloom's Taxonomy as a framework, with an example drawn from the subject of Zoology and the course Biosystematics. A sample question bank was developed and utilized to generate multiple assessment question sets. The findings highlight that a question bank designed with Bloom's Taxonomy is a valuable tool in Outcome-Based Education (OBE). It facilitates systematic evaluation, enhances conceptual clarity, identifies slow learners, and fosters critical thinking, continuous learning, research, and innovation.

Keywords: Bloom' Taxonomy, Outcome-Based Education (OBE), Zoology, Question Bank, Biosystematics.

1. INTRODUCTION

Bloom's Taxonomy, originally developed by Benjamin Bloom in 1956 and later revised in 2001, serves as a hierarchical model that classifies cognitive skills into six levels: Remember (K1), Understand (K2), Apply (K3), Analyze (K4), Evaluate (K5) and Create (K6) (Bloom *et al.*, 1956; Anderson *et al.*, 2001). This pedagogical framework is widely utilized in educational assessments to ensure a structured and progressive learning experience (Jackson, 1968; Krathwohl *et al.*, 1971; Anderson, 1983). By incorporating Bloom's Taxonomy in question bank design, educators can develop comprehensive assessments that cater to different levels of cognitive development, fostering metacognitive engagement and disciplinary literacy in biosystematics (Airasian, 1994; Etemadzadeh *et al.*, 2013; Sarkar, 2023).

The University Grants Commission (UGC), New Delhi has also emphasized the importance of developing comprehensive question banks to enhance the quality and effectiveness of assessments in higher education. In its guidelines (published in 2019), the UGC advocates for the creation of question banks as collaborative efforts among experts, aiming to produce high-quality question papers that integrate both teaching and evaluation processes (Basu and Sarkar, 2022; Sarkar, 2023). This approach ensures that assessments are aligned with educational objectives and standards, thereby fostering a more robust learning environment. Incorporating Bloom's Taxonomy into the design of these question banks further enriches the assessment process. By structuring questions across various cognitive levels (*i.e.*, from remember level to higher-order analytical and evaluative skills), educators can ensure a comprehensive evaluation of students' understanding and abilities (Krathwohl *et al.*, 1971; Anderson, 1983; Anderson *et al.*, 2001; Basu and Sarkar, 2023; Sarkar *et al.*, 2023). This approach also promotes a deeper engagement with the subject matter, facilitating a more nuanced and effective assessment of student learning outcomes.

In the context of zoology, particularly within the domain of biosystematics, Bloom's Taxonomy provides a scope of systematic approach to evaluating students' understanding of fundamental principles of taxonomy, their ability to analyse phylogenetic relationships, and their proficiency in applying cladistic methodologies. The taxonomy-based pedagogical strategy facilitates the conceptual understanding of species identifications, nomenclature and systematic classification criteria, thereby enhancing higher-order cognitive skills such as taxonomic reasoning and critical synthesis of evolutionary relationships (Mayr, 1969; Mayr and Ashlock, 1991; Kapoor, 1998).

It is assumed that a well-structured question bank using this framework ensures that students are engaged in scientific inquiry, taxonomic decision-making, and epistemological evaluation rather than mere memorization. The integration of Bloom's hierarchical cognitive model within biological taxonomy education enables learners to bridge theoretical knowledge with practical applications in systematics, leading to a more profound comprehension of biodiversity classification and evolutionary biology are sporadically emphasized.

The primary aim of this article is to develop a comprehensive question bank for the chapter on biosystematics and taxonomy in zoology, structured according to Bloom's Taxonomy framework. The objectives include:

a) **Preparation of a Question Bank under Bloom's Taxonomy Framework**: To design and curate a set of questions that align with different cognitive levels of Bloom's Taxonomy, ensuring a structured progression from basic recall (*i.e.*, remember/ understanding level) to higher-order analytical and evaluative skills (*i.e.*, evaluate/ create level).
b) **Assessment of Learning Outcomes and Course Outcomes in Biological Taxonomy**: To utilize the question bank as an evaluative tool for measuring students' conceptual understanding, analytical skills, and ability to apply taxonomic principles, ultimately aligning with the learning and course outcomes of biosystematics.

2. METHODOLOGY

2. a. Survey of Curriculum

A comprehensive review of zoology curricula from various undergraduate and postgraduate programs of various university was conducted to identify the core topics and learning outcomes related to biosystematics. The curriculum survey included syllabi from multiple universities of West Bengal, India to ensure that the question bank aligns with standard academic requirements and caters to diverse educational frameworks. This step facilitated the development of relevant questions that comprehensively cover the fundamental and advanced aspects of biosystematics.

2. b. Study on Literature

An extensive literature review was performed, focusing on two primary domains: biosystematics and Bloom's Taxonomy. The study of biosystematics literature included classical and contemporary research articles, textbooks, and scientific publications that provide insights into taxonomic principles, species classification methodologies, and phylogenetic analysis. Simultaneously, literature on Bloom's Taxonomy was examined to understand its theoretical framework, application in assessment design, and effectiveness in fostering higher-order cognitive skills. The integration of these two bodies of knowledge enabled the formulation of structured and pedagogically sound questions for the question bank.

2. c. Assessment design and analysis

In this study, assessments based on Bloom's Taxonomy to evaluate student performance across different cognitive levels has been considered. Ten batches of undergraduate and postgraduate students participated, each receiving preparatory or class tests tailored to either lower-order thinking (LOT) or higher-order thinking (HOT) skills. The LOT assessments allocated 10 to 15 marks each to Remember (K1), Understand (K2), and Apply (K3) levels, while the HOT assessments assigned 5 to 10 marks each to Analyse (K4), Evaluate (K5), and Create (K6) levels. During evaluation, the frequency of attempted, unanswered questions and marks obtained by each student are noted. The primary data was converted into secondary data for this analysis and predict the performance across different cognitive domains.

Sample Question Bank: Biosystematics according to Bloom's taxonomy

Sl. No.	Question	K-Level	Marks
1	Define biosystematics.	K1	2
2	Define biological classification.	K1	2
3	List the three main objectives of biosystematics.	K1	2
4	Identify the key contributors to the development of biosystematics.	K1	2
5	What are the different types of taxonomic classification?	K1	2
6	Name the hierarchical taxonomic ranks in biological classification.	K1	2
7	Define zoological classification.	K1	2
8	List the major taxonomic ranks used in classifying animals.	K1	2
9	Define taxonomy.	K1	2
10	Who is known as the "Father of Taxonomy"?	K1	2
11	Define alpha, beta and gamma taxonomy.	K1	2
12	What is numerical taxonomy?	K1	2
13	Mention the names of different phyla that belong to the kingdom Animalia.	K1	2

14	Mention two main characteristics of vertebrates.	K1	2
15	Define the zoological type concept.	K1	2
16	List the different types of zoological types used in taxonomy.	K1	2
17	Who introduced the type concept in zoology?	K1	2
18	Identify the significance of a type specimen in taxonomy.	K1	2
19	Define cladistics and its significance in classification.	K1	2
20	What is phenetics?	K1	2
21	How does phenetics differ from phylogenetic classification?	K1	2
22	Define DNA barcoding and mention its primary purpose.	K1	2
23	Define clad and cline?	K1	2
24	List the key principles of cladistics.	K1	2
26	Define the Biological Species Concept.	K1	2
27	Who proposed the Biological Species Concept?	K1	2
28	What is deme?	K1	2
29	List the main criteria used to define a species under the Biological Species Concept.	K1	2
30	Identify the major limitations of the Biological Species Concept.	K1	2
31	What is reproductive isolation?	K1	2
32	State the importance of reproductive isolation in the Biological Species Concept?	K1	2
33	Define sibling species.	K1	2
34	What is cryptic species?	K1	2
35	What is cosmopolitan species?	K1	2
36	Define continental species.	K1	2
37	What is super species?	K1	2
38	Define biological nomenclature.	K1	2
39	Who introduced the binomial nomenclature system?	K1	2
40	Name the international code that regulates zoological nomenclature.	K1	2
41	List the main principles of biological nomenclature.	K1	2
42	Define tautonymy.	K1	2
44	What is the basis of the hierarchical classification system?	K1	2
45	Name the seven taxonomic ranks in Linnaean classification.	K1	2
46	Explain the importance of biosystematics in biological research.	K2	3
47	Differentiate between classical taxonomy and modern biosystematics.	K2	3
48	How does taxonomy differ from systematics and classification?	K2	3
49	Describe the role of molecular techniques in biosystematics.	K2	3
50	How does phylogenetics relate to biosystematics?	K2	3
51	Illustrate the relationship between taxonomy, systematics, and biosystematics.	K2	3
52	Explain the importance of classification in zoology.	K2	3
53	Differentiate between artificial and natural classification systems.	K2	3
54	Explain ‘Downward’ and ‘Upward’ classification.	K2	3
55	Describe the key features of the three-domain system.	K2	3
56	How does molecular phylogeny contribute to zoological classification?	K2	3
57	Illustrate the differences between prokaryotic and eukaryotic classification systems.	K2	3
58	Explain the importance of zoological classification.	K2	3
59	Explain how cladistics determines evolutionary relationships.	K2	3
60	Differentiate between cladistics and phenetics with examples.	K2	3
61	Describe the process of DNA barcoding in species identification.	K2	3
62	How does phenetics classify organisms based on similarities or dissimilarities?	K2	3
63	Illustrate the principle of cladogram construction to show relationships among species.	K2	3
64	Differentiate between phylogenetic and artificial classification.	K2	3
65	Describe the concept: phenotypical basis of classification in the phylum Chordata.	K2	3
66	How does molecular taxonomy aid in classifying animals?	K2	3
67	Illustrate the differences between radial and bilateral symmetry in animals.	K2	3
68	Explain the role of type specimens in zoological classification.	K2	3
69	Differentiate between holotype, paratype, and neotype.	K2	3
70	Describe the importance of a lectotype and how it is designated.	K2	3
71	How does the zoological type concept help in species identification?	K2	3
72	Distinguish between monotypic and polytypic species.	K2	3

73	Illustrate the differences between syntypes and paralectotypes with examples.	K2	3
74	Explain the reproductive isolation as a fundamental aspect of the Biological Species Concept.	K2	3
75	Distinguish between the biological species concept and evolutionary species concept.	K2	3
76	Identify the key differences between morphospecies and paraspecies.	K2	3
77	Distinguish between allopatric and sympatric species.	K2	3
78	Differentiate between prezygotic and postzygotic barriers with examples.	K2	3
79	How does gene flow influence the classification of species according to the Biological Species Concept?	K2	3
80	How does the Biological Species Concept differ from the Morphological Species Concept?	K2	3
81	Illustrate how hybridization challenges the application of the Biological Species Concept.	K2	3
82	Explain the importance of biological nomenclature in taxonomy.	K2	3
83	Differentiate between binomial and trinomial nomenclature.	K2	3
84	How does the International Code of Nomenclature ensure uniformity in naming species?	K2	3
85	How do you apply the principles of biosystematics to classify an unknown organism?	K3	5
86	How would you use DNA barcoding to identify a species?	K3	5
87	Demonstrate the significance of phenotypic and genotypic data used in biosystematics.	K3	5
88	Prepare a dataset of morphological traits and categorize the following organisms into taxonomic groups – a) *Obelia* sp. b) *Ascaris* sp. c) *Pila* sp. d) *Pheretima* sp. d) *Balanoglossus* sp.	K3	5
89	How biosystematics helps in conservation biology?	K3	5
90	Classify the following organisms into its respective taxonomic hierarchy (upto living order) – a) *Hemidactylus* sp. b) *Varanus* sp. c) *Naja* sp. d) *Crocodylus* sp. e) *Calotes* sp.	K3	5
91	How would you determine the Phylum of the following specimens based on its characteristics? a) *Anopheles* sp., b) *Scorpion* sp., c) *Unio* sp., d) *Sepia* sp., e) Sea horse, f) Sea cucumber, g) Sea Urchin, h) *Nereis* sp., i) Sea Lily, j) Axolotl larva	K3	5
92	Demonstrate the use of dichotomous key in zoological classification.	K3	5
93	Apply the knowledge of binomial nomenclature for preparing a process flow list of naming a newly discovered organism.	K3	5
94	Predict the probable impact of advanced DNA sequencing on current classification systems.	K3	5
95	Classify the following specimens into its appropriate taxonomic ranks with suitable characters. a) *Hydra* sp. b) *Branchiostoma* sp. c) *Fasciola* sp. d) *Asterius* sp. e) *Hyla* sp.	K3	5
96	How the principles of binomial nomenclature system applied to rename a species (e.g., *Bufo* sp. to *Duttaphrynus* sp.).	K3	5
97	"Isolation is an outcome of natural selection." — Justify the statement.	K3	5
98	How might climate change impact the classification of species?	K3	5
99	Demonstrate the major limitations of evolutionary species concept.	K3	5
100	What type of specimen should be chosen for newly discovered species, and what is the justification for this choice?	K3	5
101	How would you apply the rules of the International Code of Zoological Nomenclature (ICZN) in selecting a type specimen?	K3	5
102	How is a neotype designated when the original holotype is missing?	K3	5
103	Apply the concept of a type species to define a genus.	K3	5
104	How advancements in molecular taxonomy might influence the selection of type specimens?	K3	5
105	How would you use phenetic classification to categorize a group of bacteria?	K3	5
106	Demonstrate how DNA barcoding can help in identifying an unknown species.	K3	5
107	How would you use genetic dataset to construct a phylogenetic tree?	K3	5
108	Predict how integrating cladistics and DNA barcoding can improve taxonomic classification.	K3	5
109	How would you classify organisms that reproduce asexually using alternative species concepts?	K3	5
110	Demonstrate how reproductive barriers maintain species integrity in nature.	K3	5
111	Predict how changes in habitat might affect species boundaries under the Biological Species Concept.	K3	5
112	Apply the rules of binomial nomenclature to correctly name a newly discovered species.	K3	5
113	How would you determine if a scientific name follows the principles of priority?	K3	5
114	How taxonomists resolve conflicts in species names – Demonstrate briefly.	K3	5
115	How biological nomenclature can aid in biodiversity conservation efforts?	K3	5
116	Compare and contrast morphological, molecular, and biochemical approaches in biosystematics.	K4	5

117	What are the advantages and limitations of cladistics versus phenetics in classification?	K4	5
118	Analyze how biosystematics has evolved with advancements in genetic sequencing.	K4	5
119	How does biosystematics help in understanding evolutionary relationships?	K4	5
120	Examine the role of ecological factors in species classification.	K4	5
121	Analyze the reflection of evolutionary relationships in modern classification systems.	K4	5
122	Compare between phenetic and cladistic classification methods?	K4	5
123	Examine the impact of horizontal gene transfer on bacterial classification.	K4	5
124	How do homologous and analogous structures influence classification?	K4	5
125	Compare and contrast vertebrates and invertebrates based on phenetic classification.	K4	5
126	Analyze the evolutionary relationship between reptiles, birds, and mammals.	K4	5
127	What are the key differences between the classification of arthropods and annelids?	K4	5
128	Examine the influence of homologous and analogous structures on animal classification.	K4	5
129	How does embryonic development contribute to understanding zoological classification?	K4	5
130	Compare and contrast holotypes and neotypes in terms of their designation and purpose.	K4	5
131	Analyze the role of type specimens in resolving taxonomic conflicts.	K4	5
132	What are the implications of misidentifying a type specimen in zoological classification?	K4	5
133	Examine the role of museum collections in preserving type specimens.	K4	5
134	How do type specimens contribute to the stability of zoological nomenclature?	K4	5
135	Compare and contrast cladistics, phenetics, and evolutionary systematics.	K4	5
136	Analyze the influence of molecular data on classification in cladistics.	K4	5
137	What are the strengths and limitations of DNA barcoding in taxonomy?	K4	5
138	Examine the potential for misclassification when using phenetic methods.	K4	5
139	How does convergent evolution affect the reliability of cladistic analysis?	K4	5
140	Compare and contrast the Biological Species Concept with the Phylogenetic Species Concept.	K4	5
141	Analyze the contribution of geographic isolation to speciation under the Biological Species Concept.	K4	5
142	What are the challenges of applying the Biological Species Concept to fossil organisms?	K4	5
143	How does the Biological Species Concept explain the divergence of populations over time?	K4	5
144	Explain the reasons behind changes in scientific names over time.	K4	5
145	What are the challenges in applying a universal system of biological nomenclature?	K4	5
146	Examine the impact of molecular techniques on naming species.	K4	5
147	How does homonymy and synonymy affect biological nomenclature?	K4	5
148	Analyse the 'Law of Priority' and its significance in nomenclature.	K4	5
149	Evaluate the significance of the International Code of Nomenclature in biosystematics.	K5	5
150	Justify the use of molecular phylogenetics over traditional classification methods.	K5	5
151	Assess the impact of biosystematics on biodiversity conservation.	K5	5
152	Critically analyze the limitations of the Linnaean system of classification.	K5	5
153	How effective are computational tools in biosystematics research?	K5	5
154	Assess the advantages and limitations of Whittaker's five-kingdom classification.	K5	5
155	Evaluate the significance of molecular techniques in refining biological classification.	K5	5
156	Do you agree with the current classification of viruses as non-living? Why or why not?	K5	5
157	Evaluate the roles of various larval forms found in Echinodermata in lieu of phylogeny.	K5	5
158	Assess the advantages and limitations of the phylogenetic classification system in zoology.	K5	5
159	On what basis are reptiles and amphibians placed in different taxonomic groups?	K5	5
160	Evaluate the impact of molecular phylogenetics on traditional classification methods.	K5	5
161	Assess the effectiveness of the ICZN rules in maintaining taxonomic stability.	K5	5
162	Justify the need for designating a lectotype when multiple syntypes exist.	K5	5
163	Evaluate the ethical considerations of collecting and preserving type specimens.	K5	5
164	Do you agree that molecular data should replace physical type specimens? - Justify with reasons.	K5	5
165	How effective is the type concept in addressing taxonomic disputes in zoology?	K5	5
166	Assess the advantages and disadvantages of using cladistics in modern taxonomy.	K5	5
167	Justify the use of DNA barcoding over traditional morphological classification.	K5	5
168	Evaluate the relevance of phenetics in the era of molecular taxonomy.	K5	5
169	Justify the statement with proper reason that cladistics provides a more accurate classification system than phonetics.	K5	5

170	Critically assess the role of computational tools in modern taxonomic approaches.	K5	5
171	Assess the advantages and disadvantages of using the Biological Species Concept in taxonomy.	K5	5
172	Justify why some scientists prefer the Phylogenetic Species Concept over the Biological Species Concept.	K5	5
173	Evaluate the genetic basis of origin of reproductive isolation.	K5	5
174	Evaluate the role of reproductive isolation in maintaining species diversity.	K5	5
175	Justify statement with reason that 'the Biological Species Concept is the best way to define species'.	K5	5
176	Critically assess the usefulness of the Biological Species Concept in conservation biology.	K5	5
177	Assess the advantages and limitations of binomial nomenclature over common names.	K5	5
178	Justify the importance of taxonomic revisions in nomenclature.	K5	5
179	Evaluate the effectiveness of the Law of priority in biological nomenclature.	K5	5
180	How would you argue for or against the need to modernize Latin-based nomenclature?	K5	5
181	Review a case where a species name was changed due to taxonomic reclassification and justify the decision.	K5	5
182	Develop an outline research proposal for studying species diversity in a freshwater ecosystem using biosystematics.	K6	10
183	Propose an alternative classification system that integrates both molecular and morphological data.	K6	10
184	Formulate a conservation strategy using principles of biosystematics for endangered species.	K6	10
185	Design a classification system that integrates both genetic and morphological data for naming species.	K6	10
186	Design an infographic to explain the rules of biological nomenclature.	K6	10
187	What role does DNA analysis play in changing the scientific names of species?	K6	10
188	Develop a dichotomous key for classifying a set of given species – *Scoliodon* sp., *Trygon* sp., *Labeo* sp., *Anabus* sp., *Mystus* sp.,	K6	10
189	Create a flowchart that illustrates the evolution of biological classification systems.	K6	10
190	Create a comparative chart of the major animal phyla with key characteristics.	K6	10
191	Formulate a research study on how zoological classification can aid in conservation efforts.	K6	10
192	Propose a standardized method for digitizing and preserving type specimens in museums.	K6	10
193	Develop a brief account on how a type specimen resolved a taxonomic dispute.	K6	10
194	Create an infographic illustrating the different zoological types and their significance.	K6	10
195	Design a protocol for selecting and documenting a type specimen for an animal species.	K6	10
196	Formulate a research proposal on the impact of molecular techniques on redefining zoological types.	K6	10
197	Develop a flowchart illustrating the differences between cladistics, phenetics, and DNA barcoding.	K6	10
198	Propose a new method combining DNA barcoding and cladistic analysis for species identification.	K6	10
199	Create an educational model explaining the applications of phenetics and cladistics in biodiversity studies.	K6	10
200	Formulate an outline research proposal on application of DNA barcoding to classify sympatric species.	K6	10

3. RESULTS AND DISCUSSION

Outcome-Based Education (OBE) is a learner-centric educational approach that focuses on achieving specific learning outcomes. It ensures that students not only acquire knowledge but also develop essential cognitive, analytical, and practical skills. Within the field of zoological studies, biosystematics—the scientific discipline that classifies and names organisms—plays a crucial role in understanding biodiversity, evolutionary relationships, and taxonomy (Kapoor, 1998). In OBE, Bloom's Taxonomy ensures a stepwise progression in learning, from basic knowledge acquisition to higher-order thinking skills. A well-structured question bank covering all six levels supports this progression in biosystematics (Anderson *et al.*, 2001).

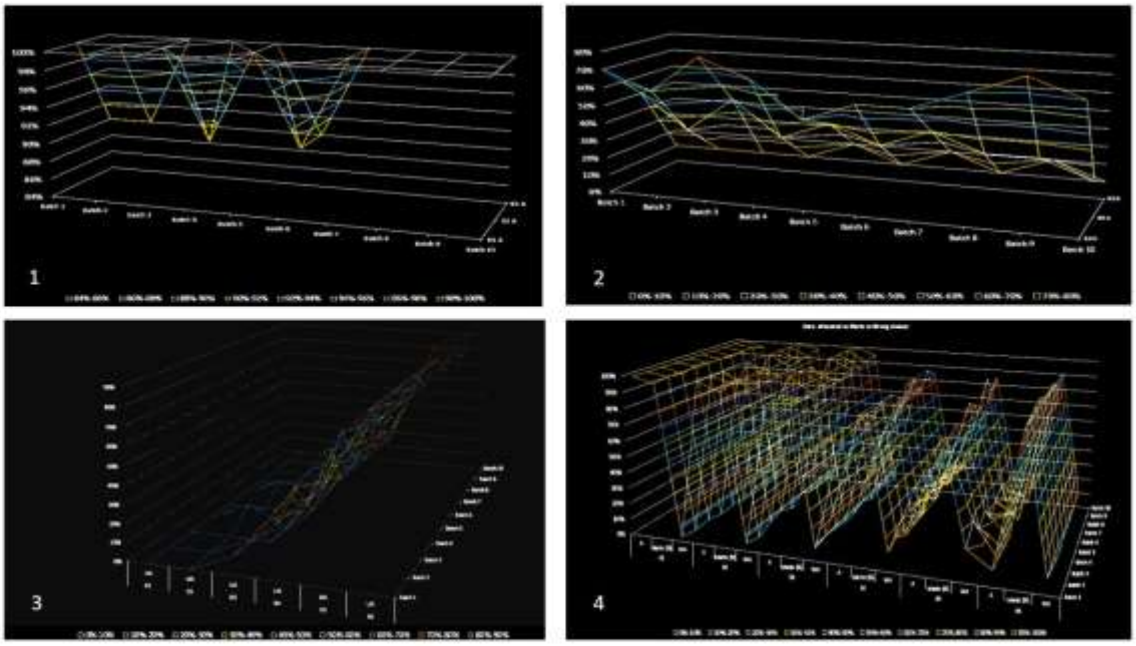
The assessment analysis of this conducted study revealed the following observations:

Table 1: presents the batch-wise distribution of attempted questions (A), unanswered questions (UA), and wrong answers (WA) in percentages. The data indicates that the tendency to attempt questions [LOT (K1, K2, K3: 70%): HOT (K4, K5, K6: 30%)] from Lower Order Thinking (LOT) is significantly higher compared to Higher Order Thinking (HOT). At the same time, the percentage of unanswered questions is considerably higher in HOT

Under graduate Level	K1			K2			K3			K4			K5			K6		
	A	**UA**	**WA**	**A**	**UA**	**WA**	**A**	**UA**	**WA**	**A**	**UA**	**WA**	**A**	**UA**	**WA**	**A**	**UA**	**WA**
Batch 1	100%	0	3%	100%	0	5%	90%	10%	8%	70%	30%	12%	50%	50%	20%	10%	90%	10%
Batch 2	100%	0	2%	100%	0	3%	90%	10%	10%	60%	40%	15%	30%	70%	30%	10%	90%	8%
Batch 3	100%	0	3%	100%	0	7%	100%	0	9%	80%	20%	10%	50%	50%	20%	10%	90%	6%
Batch 4	100%	0	1%	90%	10%	9%	100%	0	7%	70%	30%	10%	30%	70%	25%	10%	90%	5%
Batch 5	100%	0	2%	100%	0	5%	100%	0	7%	50%	50%	15%	40%	60%	15%	20%	80%	8%
Batch 6	100%	0	2%	90%	10%	10%	90%	10%	10%	60%	40%	20%	30%	70%	20%	10%	90%	8%
Batch 7	100%	0	3%	100%	0	7%	100%	0	6%	60%	40%	10%	40%	60%	25%	20%	80%	7%
Batch 8	100%	0	2%	100%	0	6%	100%	0	8%	70%	30%	20%	30%	70%	10%	10%	90%	10%
Batch 9	100%	0	2%	100%	0	6%	100%	0	7%	80%	20%	10%	30%	70%	20%	20%	80%	10%
Batch 10	100%	0	4%	100%	0	3%	100%	0	5%	70%	30%	15%	20%	80%	15%	10%	90%	10%

Table 2: provides a summary of the following observations: a) Batch-wise, students achieved maximum marks in questions from Lower Order Thinking (LOT) and lower levels of Higher Order Thinking (HOT), specifically at the K4 level. b) Students who attempted K5 and K6-level questions scored the highest marks. For instance, batch-wise students who attempted K6-level questions (with an attempt range of 10% to 20%) achieved scores between 90% and 95%. This highlights that a limited number of students excelled by answering K6-level questions, serving as a key indicator for identifying fast or advanced learners at the undergraduate level

Under graduate Level	K1			K2			K3			K4			K5			K6		
	A	**Marks (%)**	**WA**	**A**	**Marks (%)**	**WA**	**A**	**Marks (%)**	**WA**	**A**	**Marks (%)**	**WA**	**A**	**Marks (%)**	**WA**	**A**	**Marks (%)**	**WA**
Batch 1	100%	97%	3%	100%	95%	5%	90%	92%	8%	70%	88%	12%	50%	80%	20%	10%	90%	10%
Batch 2	100%	98%	2%	100%	97%	3%	90%	90%	10%	60%	85%	15%	30%	70%	30%	10%	92%	8%
Batch 3	100%	97%	3%	100%	93%	7%	100%	91%	9%	80%	90%	10%	50%	80%	20%	10%	94%	6%
Batch 4	100%	99%	1%	90%	91%	9%	100%	93%	7%	70%	90%	10%	30%	75%	25%	10%	95%	5%
Batch 5	100%	98%	2%	100%	95%	5%	100%	93%	7%	50%	85%	15%	40%	85%	15%	20%	92%	8%
Batch 6	100%	98%	2%	90%	90%	10%	90%	90%	10%	60%	80%	20%	30%	80%	20%	10%	92%	8%
Batch 7	100%	97%	3%	100%	93%	7%	100%	94%	6%	60%	90%	10%	40%	75%	25%	20%	93%	7%
Batch 8	100%	98%	2%	100%	94%	6%	100%	92%	8%	70%	80%	20%	30%	90%	10%	10%	90%	10%
Batch 9	100%	98%	2%	100%	94%	6%	100%	93%	7%	80%	90%	10%	30%	80%	20%	20%	90%	10%
Batch 10	100%	96%	4%	100%	97%	3%	100%	95%	5%	70%	85%	15%	20%	85%	15%	10%	90%	10%



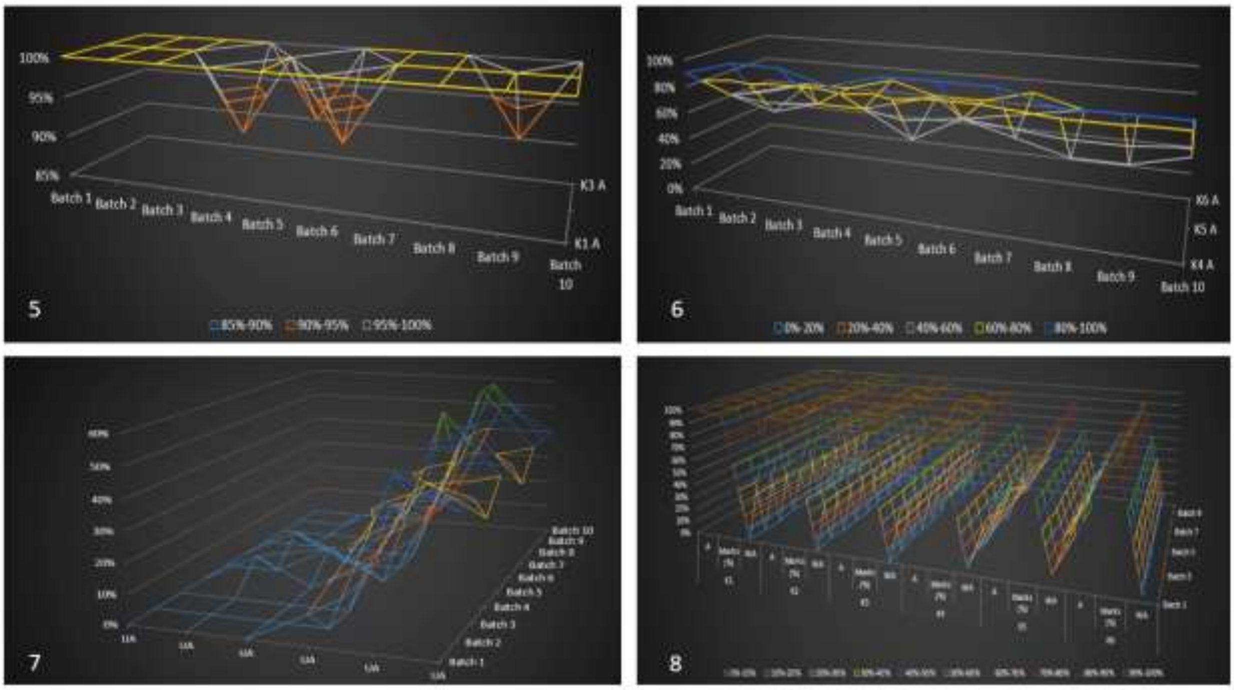
Figures 1–4: illustrate various findings from the assessments. Figures 1 and 2 depict the variation in attempted questions within Lower Order Thinking (LOT) and Higher Order Thinking (HOT), respectively. Figures 3 and 4 show the batch-wise variation in unanswered questions, highlighting a significant tendency to leave questions unanswered at the Knowledge Level 6 (K6) level among undergraduate students. A small percentage of students attempted K6-level questions, yet those who did managed to achieve high scores in both HOT and LOT categories.

Table 3: presents the batch-wise distribution of attempted questions (A), unanswered questions (UA), and wrong answers (WA) in percentages. At the postgraduate (PG) level, the tendency to attempt questions [LOT (K1, K2, K3: 50%): HOT (K4, K5, K6: 50%)] from Lower Order Thinking (LOT) is notably higher compared to Higher Order Thinking (HOT). Similarly, the percentage of unanswered questions is significantly greater in HOT. Compared to the undergraduate (UG) level, a noticeable shift is observed in the tendencies for attempted (A) and unanswered (UA) questions

Post graduate Level	K1			K2			K3			K4			K5			K6		
	A	UA	WA	A	UA	WA	A	UA	WA	A	UA	WA	A	UA	WA	A	UA	WA
Batch 1	100%	0	2%	100%	0	1%	100%	0	1%	90%	10%	5%	60%	40%	10%	50%	50%	5%
Batch 2	100%	0	1%	100%	0	3%	100%	0	1%	100%	0	10%	50%	50%	10%	60%	40%	7%
Batch 3	100%	0	1%	100%	0	1%	100%	0	3%	100%	0	6%	60%	40%	20%	60%	40%	5%
Batch 4	100%	0	3%	90%	10%	1%	100%	1%	1%	90%	10%	8%	60%	40%	15%	70%	30%	4%
Batch 5	100%	0	2%	100%	0	1%	90%	10%	1%	100%	0	9%	40%	60%	15%	60%	40%	9%
Batch 6	100%	0	2%	90%	10%	3%	100%	0	1%	100%	0	2%	60%	40%	10%	60%	40%	7%
Batch 7	100%	0	1%	100%	0	2%	100%	0	8%	100%	0	10%	50%	50%	15%	70%	30%	8%
Batch 8	100%	0	3%	100%	0	4%	100%	0	5%	90%	10%	10%	40%	60%	10%	60%	40%	9%
Batch 9	100%	0	2%	100%	0	3%	90%	10%	3%	90%	10%	5%	40%	60%	10%	60%	40%	6%
Batch 10	100%	0	1%	100%	0	3%	100%	0	6%	90%	10%	10%	50%	50%	15%	60%	40%	8%

Table 4: summarizes the following observations at the postgraduate (PG) level: a) Batch-wise, students achieved the highest marks in questions from Lower Order Thinking (LOT) and the lower levels of Higher Order Thinking (HOT), specifically K4 and K5 levels. This is a pattern similar to what was observed at the undergraduate (UG) level. b) Students who attempted K5 and K6-level questions scored exceptionally well. For example, batch-wise students who attempted K6-level questions (with an attempt range of 50% to 70%) achieved scores between 91% and 96%. This indicates that a small number of students excelled in K6-level questions, serving as a key indicator for identifying advanced learners or research-oriented students at the PG level.

Post graduate Level	K1			K2			K3			K4			K5			K6		
	A	Marks (%)	WA	A	Marks (%)	WA	A	Marks (%)	WA	A	Marks (%)	WA	A	Marks (%)	WA	A	Marks (%)	WA
Batch 1	100%	98%	2%	100%	99%	1%	100%	99%	1%	90%	95%	5%	60%	90%	10%	50%	95%	5%
Batch 2	100%	99%	1%	100%	97%	3%	100%	99%	1%	100%	90%	10%	50%	90%	10%	60%	93%	7%
Batch 3	100%	99%	1%	100%	99%	1%	100%	97%	3%	100%	94%	6%	60%	80%	20%	60%	95%	5%
Batch 4	100%	97%	3%	90%	99%	1%	100%	99%	1%	90%	92%	8%	60%	85%	15%	70%	96%	4%
Batch 5	100%	98%	2%	100%	99%	1%	90%	99%	1%	100%	91%	9%	40%	85%	15%	60%	91%	9%
Batch 6	100%	98%	2%	90%	97%	3%	100%	99%	1%	100%	98%	2%	60%	90%	10%	60%	93%	7%
Batch 7	100%	99%	1%	100%	98%	2%	100%	92%	8%	100%	90%	10%	50%	85%	15%	70%	92%	8%
Batch 8	100%	97%	3%	100%	96%	4%	100%	95%	5%	90%	90%	10%	40%	90%	10%	60%	91%	9%
Batch 9	100%	98%	2%	100%	97%	3%	90%	97%	3%	90%	95%	5%	40%	90%	10%	60%	94%	6%
Batch 10	100%	99%	1%	100%	97%	3%	100%	94%	6%	90%	90%	10%	50%	85%	15%	60%	92%	8%



Figures 5–8: depict various findings from the assessments at the postgraduate (PG) level. Figures 5 and 6 show the variation in attempted questions within Lower Order Thinking (LOT) and Higher Order Thinking (HOT), respectively. Figures 7 and 8 illustrate the batch-wise variation in unanswered questions, highlighting a prominent tendency to leave Knowledge Level 6 (K6) questions unanswered at the PG level.

Key Observations:

1. **Undergraduate Level:**
    - **LOT (K1-K3):** 70% of assessments
    - **HOT (K4-K6):** 30% of assessments

Students performed better in LOT questions, with a higher tendency to leave HOT questions unanswered. For instance, only 10%-20% of students attempted K6-level questions but achieved high scores (90-95%).

2. **Postgraduate Level:**
    - **LOT (K1-K3):** 50% of assessments
    - **HOT (K4-K6):** 50% of assessments

A significant shift was observed at the postgraduate level, with 50%-70% of students attempting K6-level questions and achieving scores between 91%-96%. This indicates an increased focus on higher-order cognitive skills and research orientation.

From the above mentioned observations, the significance of the implementation of Bloom's framework in question bank is clearly noted. The ultimate objective of a Bloom's-Based Question Bank in Biosystematics are summarized below

a) *Enhancing Conceptual Understanding*

Biosystematics involves complex principles, including phylogenetic relationships, species identification, and evolutionary classification. By structuring a question bank using Bloom's Taxonomy, educators can guide students from basic recall (example: 'Define taxonomy') to higher-order (example: 'Propose a new method combining DNA barcoding and cladistic analysis for species identification.') applications. This ensures deep understanding rather than memorization.

b) *Promoting Analytical and Critical Thinking*

A question bank that incorporates higher-order questions (*i.e.,* analyse, evaluate, create) enables students to critically assess taxonomic data and propose solutions to classification challenges. For example, questions like "Design a protocol for selecting and documenting a type specimen for an animal species." encourage students to critique existing knowledge and explore innovations in biosystematics.

c) *Facilitating Progressive Learning*

Since Bloom's-based questions are structured in increasing levels of difficulty, they help students advance systematically in their learning journey. Initial questions focus on factual recall, gradually leading to complex problem-solving scenarios. This scaffolding supports different learning paces and ensures that all students reach the desired competencies in biosystematics under zoological studies.

d) *Supporting Outcome-Based Assessment*

In OBE, assessment is aligned with learning outcomes. A Bloom's-based question bank provides a reliable framework for designing exams, quizzes, and assignments that accurately measure whether students have attained the intended learning outcomes. For instance, if a course outcome is to develop expertise in species identification, questions should assess the ability to apply classification principles rather than merely recalling definitions.

e) *Encouraging Research and Innovation at PG level*

The highest levels of Bloom's Taxonomy—(*i.e.,* evaluate and create) motivate the students towards independent research and innovative thinking. In biosystematics, this could involve developing new classification models or proposing revisions to existing taxonomic frameworks. Questions like "Develop a case study on a real-world example where the Biological Species Concept has been challenged" encourage original thought and application of learned principles.

If students in a batch have strong foundational knowledge, they are likely to achieve higher cognitive level of course outcomes (COs). Conversely, weaker prior knowledge may result in lower attainment unless corrective measures are implemented. If the knowledge level of a batch is assessed early, additional teaching strategies, like remedial sessions, peer learning, or flipped classrooms, can be introduced to boost attainment. More effectively, integration of Bloom's-based question bank in biosystematics, the following strategies may be adopted:

- **Diversification of Question Types:** It is proposed to include multiple-choice type questions for lower-order cognition, case studies for application and analysis, and open-ended research prompts for evaluation and creation level.
- **Integration with Practical Activities:** Questions should be linked to laboratory work, field studies, and research projects to provide real-world context (Airasian, 1994).
- **Periodic Assessment and Feedback:** Regular formative assessments using the question bank allow educators to track student progress and adjust teaching strategies accordingly (Krathwohl and Payne, 1971; Etemadzadeh *et al.,* 2013).
- **Use of Technology:** Digital question banks can facilitate adaptive learning, where question difficulty adjusts based on student performance. The integration of Information and Communication Technology (ICT) tools plays a crucial role in the effective implementation of Bloom's Taxonomy within the question bank framework. Digital learning platforms, such as Learning Management Systems (LMS), automated assessment tools, and interactive software, enable educators to design adaptive and diverse question formats that align with different cognitive levels (Sarkar, 2023).

CONCLUSION

A Bloom's-based question bank in biosystematics is integral to OBE in Zoological studies. It enhances conceptual understanding, promotes critical thinking, ensures progressive learning, and fosters innovation. By implementing a structured approach, educators can prepare students with the skills needed for careers in taxonomy, conservation, and biodiversity research. The incorporation of Bloom's Taxonomy will ensures systematic evaluation, helping educators identify advanced learners and support all students in achieving their academic success.

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REFERENCES

- Airasian, P. W. (1994). The impact of the taxonomy on testing and evaluation. In L.W. Anderson & L. A. Sosniak (Eds.), *Bloom's taxonomy: A forty-year retrospective: Ninety-third yearbook of the National Society for the Study of Education* (pp. 82–102). Chicago: University of Chicago Press.
- Anderson, J. R. (1983). *The architecture of cognition.* Cambridge, MA: Harvard University Press.
- Anderson,L.W., Krathwohl, D. R., Airasian, P. W., Cruikshank, K. A., Mayer, R. E., Pintrich, P. R., *et al.* (Eds.). (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. New York: Longman.
- Bloom, B. S., Engelhart, M. D., Furst, E. J., Hill, W. H.,& Krathwohl, D. R. (Eds.).(1956). *Taxonomy of educational objectivities: The classification of educational goals. Handbook I: Cognitive domain.* New York: David McKay.
- Bloom, B. S., Hastings, J. T., & Madaus, G. F. (1971). Handbook on formative and summative evaluation of student learning. New York: McGraw-Hill.
- Jackson, P. W. (1968). *Life in classrooms.* New York: Holt, Rinehart and Winston.
- Krathwohl, D. R., & Payne, D. A. (1971). Defining and assessing educational objectives. *In:* R. L. Thomdike (Ed.), *Educatumal measurement* (pp. 17-45). Washington, DC: American Council on Education.
- Kapoor, V. C. (1998). Theory and Practice of Animal Taxonomy (4th edition) 247 pp. Oxford& IBH Publishing Co. Pvt. ltd. New Delhi.
- Mayr, E. (1969). Principles of Systematic Zoology, McGraw-Hili, INC, New York.
- Mayr, E. and P. D. Ashlock, (1991). Principles of Systematic Zoology (2nd ed.). Mc Craw Hill, INC. New York.
- Mayr, E., E. G. linsley, and R. l. Usinger, (1953). Methods and Principles of Systematic Zoology McCraw-Hili Book Company, INC, New York, Toronto & London: 1-336.
- Sarkar, S. K. (2023) Bloom's Taxonomy and Examination Reform in Higher Education using ICT as a Tool. *J Adv. Edu. Phil.*, 7(5): 173-177.
- Basu, S., & Sarkar, S. K. (2022). Revisiting the History of Indian Education Policies. *Int. J Innov. Res. Multidisc. Fields*, 8(9), 257- 265. doi: 10.2015/IJIRMF/202209042
- Basu, S., & Sarkar, S. K. (2023). Recent Trends in Digital Evaluation of Answer Scripts as a Mark of Examination Reform. *Int. J Innov. Res. Multidisc. Fields*, 9(4), 118- 120. doi:10.2015/IJIRMF/202304021
- Sarkar, S. K., Basu, S. & Bhattacharya, T. (2023). ICT Based Examination Reform: An Ultimate Solution to Conduct CBCS Pattern of Assessment in India. *J Adv. Edu. Philos.*, 7(10): 396-401.
- Etemadzadeh, A., Seifi, S., & Far, H. R. (2013). The role of questioning technique in developing thinking skills: The ongoing effect on writing skill. *Procedia Social and Behavioral Sciences*, 70, 1024 1031.
- University Grants Commission (2019). Evaluation Reforms in Higher Educational Institutions. Secretary, UGC, New Delhi.

