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Use of a Novel Typological Chart Study in Zoology to Improve the Learning Outcomes

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ABSTRACT

Background: Animals are organized and classified relative to their evolutionary links and commonalities in an approach termed taxonomy. The strategies used to explain classification and build the students' research foundation are provided in the text and visual series of catalogues, educational publications, illustrations, scientific works, graphics, and images.

Methods: Students in higher education learning zoology were the intended target group for assessing their compatibility and drawing conclusions with a source of one-page typological charts of vertebrates and invertebrates. The colored boxes indicated the rank; imagery as supplements, acronyms to assist users in recalling the scientific names together; and the names of the scientists who classified the organisms are featured in the one-page tumbling charts. The classroom research study was split into two groups where G-I was based on the traditional study model and G-II on the typological chart study model.

Results: The statistical data analysis of the classroom research reported the enhancement in the learning skills of students in G-II as compared to the traditional mode of study. The Copyright Office of the Government of India registered the one-page classification charts of invertebrates and vertebrates with registration numbers L-86868/2019 and L-87961/2019 due to its uniqueness.

Conclusion: Detailed classification of vertebrates and invertebrates is challenging due to the extensive diversity, but a simplified and condensed version of the classification fit on a single page may prove to engage the reader's interest.

Key-words: Comprehensive chart, Invertebrate classification, One-page chart, Typological plot, Vertebrate classification, Zoology

INTRODUCTION

The primary focus of this area of biology is the scientific study of animals, and zoology is a broad field with numerous facets. The numerous aspects of zoology include behavior, ecology, physiology, anatomy, diversity, taxonomy, distribution, and so forth. The primary and challenging duty in a diverse animal world is classifying organisms according to their morphological and anatomical traits as well as the evolutionary links between multiple categories. Aristotle, a Greek philosopher and renowned scientist, is regarded as the father of taxonomy. The authors categorized the animals according to their morphology, reproduction, & habitat. In 350 BC, published the book "History of Animals" established the taxonomy of organisms into five categories: invertebrates, fish, reptiles, birds, and mammals [1]. Carl Linnaeus, a Swedish zoologist, botanist, and physician, is credited as the father of modern taxonomy, while he was the first to propose a hierarchical system for classifying and organizing every living being. He also introduced binomial nomenclature and wrote the book “Systema Naturae” in 1735 [2]. The cladistics approach of classification in which a clade is the basic unit and focuses on evolutionary history and synapomorphies is not much suited to classification compared with the non-cladistics/ traditional approach that utilizes taxonomic ranks [3]. To determine the systematic position of a set of unidentified samples, the samples were compared to the cladistics; and their phylogenetic relationships were used to determine the evolutionary classification [4]. All of the work cited here showed animal classification helps to ease studying the

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organism's position and learning according to the groups or ranks.

There are some fundamental problems in the Linnaean hierarchy and some modifications are expected in the traditional classification of biology [5]. Students do not show interest in learning biology due to the difficulty in understanding, memorizing, and analyzing the scientific terms and complicated study material. The intrinsic motivation of a student to learn a subject is not affected by external factors but the extrinsic motivation coming from the subject material available in the institutes that needs to be easy and interesting [6]. To overcome the hurdles in learning biology use of some newer techniques like the use of visual materials, précising the curriculum, modifying the study designs, linking the subject with daily life, and making the biology subject more interesting could be done [7]. A study says that the students recognize the broader category (phyla) but failed to identify the sub-categories (class, order) concluding that the classification pattern and techniques in the present scenario are inadequate concerning animal learning [8].

According to one study, a significant portion of all age groups (513 students) was unable to generalize and distinguish between examples and non-examples of animals (amphibians & reptiles) when given classification tasks at the elementary, secondary, and college levels. This led to a wide range of alternative conceptions [9]. Consequently, most students abandon studying classification since they become confused, which undermines their comprehension of zoology in general. Additionally, throughout the exam, students overlook and skip certain questions. As a result, everyone acknowledges that the categorization system for invertebrates and vertebrates is intricate, branched, and full of resilient terminology that is challenging to learn, memorize, and remember. To solve these problems, innovation in this sector is thus needed.

Hybrid and blended modes of learning are also gaining much attention after the pandemic due to their applicability and evolution with time. In a study of more than 800 samples of students who learned 33 sections of biology educated by 16 different instructors, it was observed that the students following the flipped active learning sections gave significant results when compared with the peer group of students who learned traditional sections by didactic pedagogy [10]. When students were given three treatments on weekly rotations comprising of discussion, writing, and both (discussion & writing), this mixed effect model significantly improved the student's aptitude, scores, and performance in exam essays [11]. This implies that the instructor needs to be more innovative and proactive in encouraging students to think creatively and beyond the box.

The complexity, diversity, cryptic species, variations, hybridization, convergent evolution, lack of information or data on certain species, unclear positions of some organisms, and other factors complicate zoology (Fig. 1). Given that taxonomists have differing opinions about how to interpret the given evidence, some animals are still not categorized. Another issue that students have while learning zoology is the vastness of information, complex terminology, interdisciplinary nature, lack of presentation by visualization and hands-on experience, abstract thinking, continuous updating, and varied learning styles (Fig. 2).

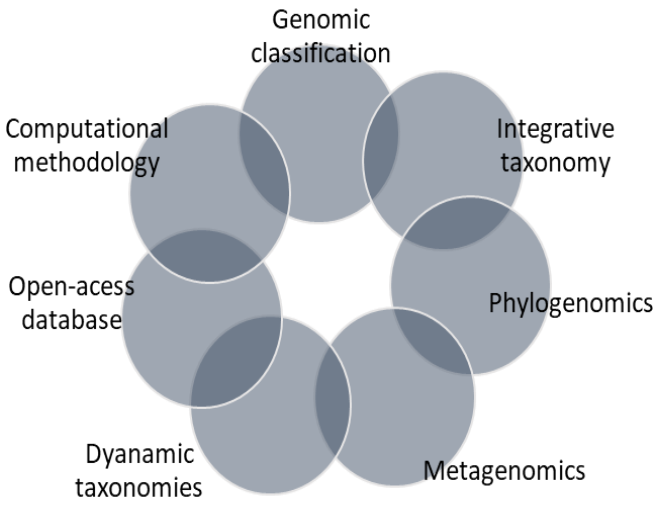

Fig. 1: Emerging fields of Zoology Taxonomy

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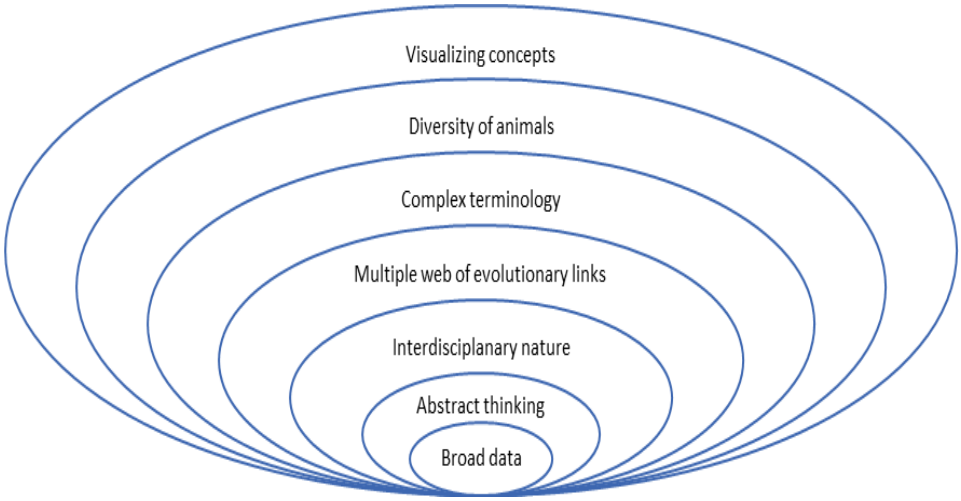

Fig. 2: Challenges to learn Zoology

MATERIALS AND METHODS

In December 2023, a pilot study was conducted with students at the University of Rajasthan in Jaipur, Rajasthan, India. The students were given study material (charts) as a flipped model assignment in a regular class.

Target community- Concerning animal taxonomy, there is an immense gap between what scientists know and what students are trying to learn. To bridge this knowledge gap, an innovative idea of compressing the vertebrate and invertebrate groupings onto a single page was created and established, facilitating the understanding of the subject matter clearly among graduate and postgraduate students.

The need for a learner- The categorization of animals is incredibly intricate for students to use to mark their memory. The classification of vertebrates and invertebrates, in tandem with their respective divisions/categories (phylum, class, order, etc.), are laid out in distinct chapters and are consequently dispersed across the taxonomy text and reference books.

Specification- A simplified one-page classification chart or tumbling chart of vertebrates and invertebrates (Fig. 3 & 4) provides a broad overview of major taxa phyla, subphyla, classes, subclasses, orders, and suborders in an organized manner. To make it easier for students to understand the hierarchical structure, different colored blocks or boxes are utilized to demarcate distinct groups, which denote phylum, subphylum, class, etc. For instance, in an invertebrate chart, the phylum, subphylum, class, and subclass are represented by boxes that are colored blue, red, purple, and pink, respectively. A figure depicting the representative organism for each category or block provided in a chart is an innovative educational approach for the students. Various methods of teaching zoology classification may include the use of abbreviations, metaphors, and analogies to render complex terms easier to grasp. The supporting words or phrases that go beneath the blocks in this tabular chart are also included to enable the student to effortlessly learn a variety of names in one go. The phylum Platyhelminthes is divided into three classes, Turbellaria, Trematoda, and Cestoda, which can be identified by the abbreviation TTC, which is used for Train Ticket Checker. To pinpoint the exact location of the groupings, numerical columns and rows are also used to justify the phrases {for instance, TTC marked in column 7 and row (1-3)}. The names of the scientists whose classification is followed in the chart are also included, as there is considerable variation in the approaches employed to comply with the classification. For example, Protozoa, Coelenterata, and Aves were most likely classified by B.M. Hornberg, L.H. Hayman, and A. Wetmore. All of the aforementioned innovations are condensed into a single page that highlights their uniqueness and specialization, which appeals to the expectations of today's learners who demand ease and convenience in everything. Because of this, the tabular classification chart is distinguished from other learning resources and is more engaging. Tumbling Chart of Vertebrate Classification and Tumbling Blocks of Invertebrate Classification are registered with registration numbers L-86868/2019 and L-87961/2019, respectively, in the Copyright Office, of the Government of India due to their uniqueness.

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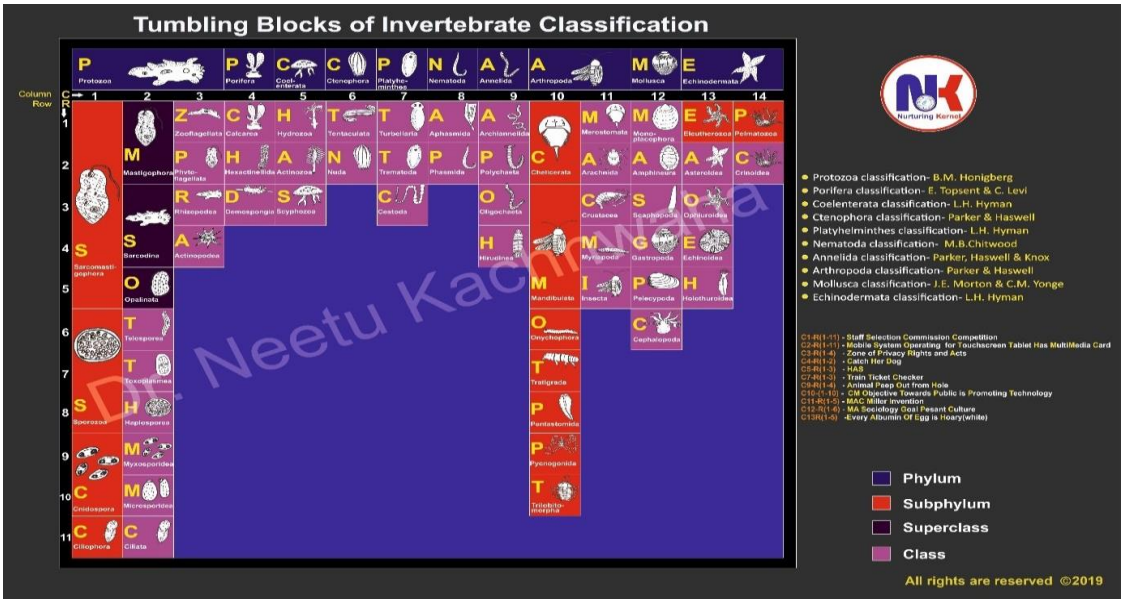

Fig. 3: One-page classification chart of invertebrates

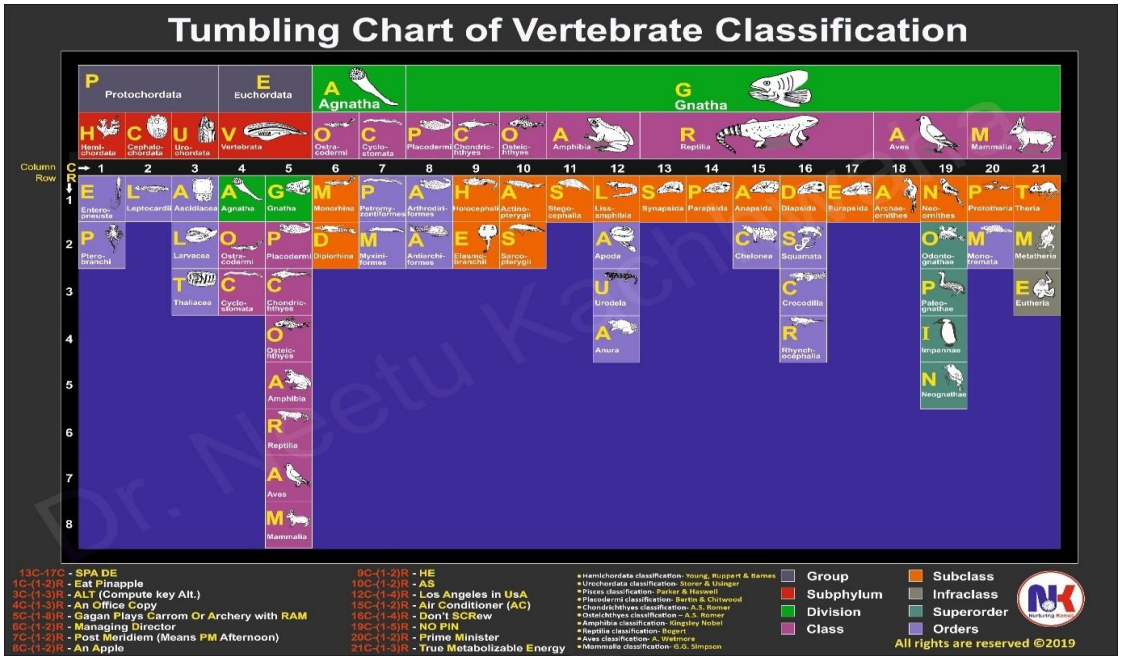

Fig. 4: One-page classification chart of vertebrates

Research Design- The classroom research model which is a cyclic process that includes the intentional inquiry by a teacher or professional to know their classroom work was used. The author has conducted the research in consecutive steps of observing, inquiring, asking, planning, implementing, analyzing, and reflecting [12] as shown in Fig 5. This technique was utilized to evaluate the learning outcome using the innovative idea of typological charts. The quiz investigated was the single basis of designing and concluding the evidence to support the typological charts. The study was conducted in two groups: Group I (G-I) followed the traditional teaching-learning model and Group II (G-II) followed the typological chart study model. In G-I, the classification of invertebrates and vertebrates was taught conventionally in a regular class. As a class activity, 25 students participated in a test conducted by providing a questionnaire with 50 multiple-choice questions to answer in 30 minutes. The instruction was given to attempt all the questions. The students were asked questions from the classification and taxonomy sub-discipline. In G-II, the same students were provided classification charts, and seven days were given to become conversant and retain the information. The test activity was rescheduled for animal classification with new questions.

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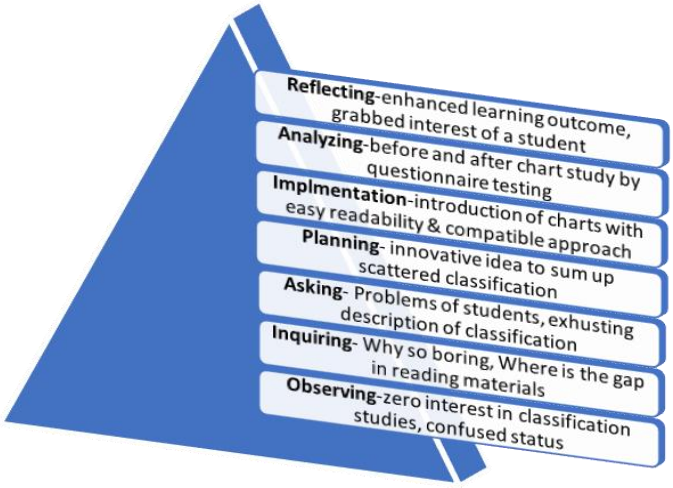

Fig. 5: Classroom research study showing steps of formulating and concluding the student's concept

Table 1: Student responses to the questionnaire

NS	CA (G-I)	IA (G-I)	TN (G-I)	CA (G-II)	IA (G-II)	TN (G-II)
1	17	33	30	23	27	30
2	13	37	28	19	31	28
3	18	32	29	31	19	25
4	18	32	30	20	30	20
5	15	35	30	17	33	25
6	15	35	30	23	27	26
7	13	37	30	18	32	27
8	17	33	25	19	31	20
9	16	34	24	16	34	30
10	13	37	27	20	30	30
11	11	39	20	18	32	25
12	19	31	30	29	21	26
13	19	31	30	22	28	25
14	9	41	29	28	22	26
15	15	35	28	28	22	23
16	28	22	30	33	17	22
17	14	36	30	22	28	25
18	22	28	30	23	27	26
19	20	30	28	26	24	28
20	20	30	29	21	29	30
21	18	32	20	35	15	20
22	21	29	30	32	18	25
23	17	33	30	28	22	25
24	21	29	30	26	24	25
25	23	27	30	35	15	20
Total	432	818	707	612	638	632
Average mean	17.28	32.72	28.28	24.48	25.52	25.28
Mode	17	33	30	23	27	27

Where; NS: Number of students, CA (G-I): Total number of correct answers Group-I without chart, IA (G-I): Total number of answers incorrect Group I without charts, TN (G-I): Time needed by the student for submission in Group I, CA (G-II): Total number of correct answers Group -II with charts, IA (G-II): Total number of answers incorrect Group II with charts, TN (G-II): Time needed by the student for submission in Group II

Statistical Analysis- After getting the data table, the significance and correlation between the two groups were assessed using Pearson's correlation coefficient and the Student's t-test in Microsoft Excel.

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RESULTS

Through an analysis of the discrepancies between the study materials given to students in traditional learning environments and their needs, the class research model proved essential in concluding. After having an intensive discussion and determining the sample group's issue, the idea to create one-page classification charts of vertebrates and invertebrates emerged. The analysis of the two groups' responses showed that G-I students gave more incorrect answers and took longer periods to complete problems. G-II showed quicker and more precise answers than G-I (Table 1, Fig. 6). Students who studied the charts for seven days exhibited transformations in their performance and ability. This indicates that the chart will undoubtedly pique their attention and allow them to improvise their subject if offered in a regular teaching and learning method.

The tools and techniques used to learn difficult subjects such as zoology are continuously evolving. Accepting the most recent developments in zoology may be sometimes, hampered by methodological and technical constraints. Therefore, breaking scientific information into manageable, clarified, and interactive learning could spark a student's interest. The charts provide additional resources for teachers and students to present and learn the basics of zoology. The student can utilize a printed copy of the chart and display it so that, they can see the table any minute and memorize it rapidly and effortlessly. As reported by research, the flipped classroom approach not only blends synchronous and asynchronous learning but also enhances the quality of discussion and interaction in the classroom [13]. Here, the blended learning approach of the flipped classroom may also be used to augment the typological charts as an additional advantage.

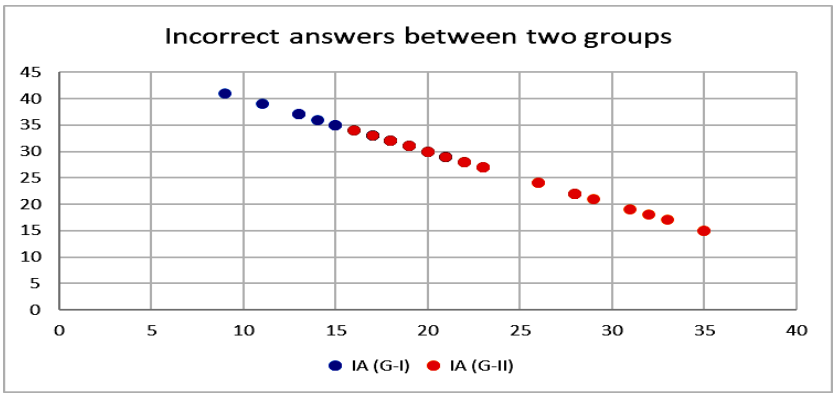

Fig. 6: Graphical presentation of data showing the comparison of two groups (G-I, G-II) concerning their incorrect answers

Table 2: Group Statistics

Groups	Number	Mean	Standard Deviation	Standard error
G-I	25	17.28	4.05	0.81
G-II	25	24.48	5.65	1.13

The modes were calculated for comparing students' performance using charts (G-II) and without charts (G-I) which were found to be 23 and 17 for the number of correct answers delivered. For further analysis, the mean of G-II and G-I was estimated to be 24.48 and 17.38. Student's t-test was performed to test the significant difference between the two groups. The determined values of G-I (M=17.38, SD= 4.05) and G-II (M=24.48, SD=5.65) referred to in Table 2; and the calculated value of $t(48)$ was 5.07 which showed a highly significant difference between groups with $p=6.31x10^{-06}$.

Also in the statistical analysis, when correlation was observed in submitting the answer sheets with the time given (30 minutes), it was reported that G-II has taken a mean average time of 25.28 minutes as compared to 28.28 minutes in G-I with a lesser number of errors (incorrect answers) presented by calculated mode (G-II-27 and G-I-33) in a week study with typological charts. Thus, G-II illustration is significantly superior to G-I. Pearson's correlation coefficient of parametric data was also statistically calculated as given in Table 3.

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Table 3: The Pearson's correlation between two groups (G-I and G-II)

	CA (G-I)	IA (G-I)	TN (G-I)	CA (G-II)	IA (G-II)	TN (G-II)
CA (G-I)	1					
IA (G-I)	-1	1				
TN (G-I)	0.30	-0.30	1			
CA (G-II)	0.52	-0.52	0.11	1		
IA (G-II)	-0.52	0.52	-0.11	-1	1	
TN (G-II)	-0.30	0.30	0.12	-0.45	0.45	1

The interpretation of data presented in colored boxes: Orange colored block-very high negative correlation, blue colored block-moderately positive/negative correlation, green colored block- low positive/negative correlation

DISCUSSION

A study explored that a change in teaching strategy and active learning of the students not only enhances skill analysis and critical thinking but also explores their practical thinking and practical experiences [14]. The charts actively engaged the learner group due to their colorful blocks, sketches of animals, and learning phrases.

With the revolutionary era of technology, the student demands ease in the complexity of study material and needs the integration of transversal skills which are not learned through traditional classroom teaching [15]. To make study more practical, engaging, and educational, information and communication technologies (ICTs) are currently receiving increased attention in the field of education. Both educators and students are adopting new teaching tools that will enable them to effectively teach and learn about animal evolution and diversity [16]. There are some examples where the use of ICT and innovations simplified the study patterns and evolved the learning skills. In an exclusive e-book, some scientists defined thirteen thousand names from the invertebrate phylum, which included Bryozoa, Entoprocta, Mesozoa, Mollusca, Nematoda, Onychophora, Platyhelminthes, Loricifera, etc. to provide a sum up configuration [17]. The didactic books were analyzed to specify the class taxon of Pisces, and most analogies were found to be present in invertebrates rather than in vertebrates [18]. A fish dataset was established in Pakistan to identify 33 thousand species by using high-quality images as visual characteristics with the aid of computer and machine learning technology [19]. The vertebrate classification in zoology was evaluated by qualitative and quantitative analysis in biology students with the help of the determination key. The results revealed a significant correlation between concept attainment and classification ability [20]. Biology students improved their classification skills and identified birds with the aid of the smartphone application i-Bird, as reported by some scientists [21]. Although the technologies grabbed the interest of the students very well, for their mental, social, and physical well-being higher education needs to be more focused on sustainable education and the incorporation of few physical exercises [22]. The charts offer active learning without compromising the well-being of a learner by providing flexibility to carry the charts anywhere, and no use of any digital technology.

The graphs, figures, plots, and tables used as supplementary material always prove to be a vital tool that presents the data with simplicity and clarity within the limited word of explanation. The saving of the time and energy of the learners is the additional advantage of these tools as they are self-explanatory and provide added value to a text [23]. The self-explanation of the typological chart of vertebrates and invertebrates complements the subdiscipline, summarizes the essential component of zoology classification, is colorful, and attractive, and showcases the technical expertise of the author. Well, the amount of vision about the supplementary charts motivated the self-learning of a student but the small proportion of the sample study limits the generalized view of the results. To provide a more comprehensive view of the responses, further investigation will be encouraged and emphasized through the study prospectus in a large sample of students.

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CONCLUSIONS

The globe is expanding at a pace that makes it necessary to integrate technology and develop new educational ideas that can aid students in transforming their learning perspectives and improving their capacity to classify information. Researchers, zoologists, biologists, and taxonomists are the scientists frequently working on the identification and development of novel approaches that can ease learning. Typological studies need to be advanced and compatible with students' mindsets. The classification charts pictured the concept with simplicity, tables presented the exact values of the interpretation of the student's review, and statistical data supported the research.

The charts can be used as study material in a regular under the flipped model (blended learning) to strengthen their knowledge about animal classification. Hence, the chart offers a new-age tool for studying zoological classification in an authenticated and defined compressed manner.

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CONTRIBUTION OF AUTHORS

The research concept, development of the charts, making the research design, data collection, analysis and interpretation, literature search, writing the article, critical review, article editing, and final approval were done by the sole author.

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