Anirban Roy (Doctoral Scholar (JRF)
anirbanroy247@gmail.com
Sushmita Singh
sush.audi2k13@gmail.com

Investigating the Learning Gaps of Senior-secondary Children through Original (Real-life) Biological Images: What Really Lacks?

Abstract

The dismal learning levels of students in our school(s) posit a putative question on the institutional failure of the Nation's education system. But this comes as no surprise, given the prevailing priorities of our education system lie only with rote memorization and good score(s) in the examinations. In pursuit of finishing the syllabus within a stipulated time, teachers often completely ignore the "learning gaps" being imbibed by the child. One of the more consequential features of learning gaps is their tendency, if left unaddressed, to compound over time and become more severe and pronounced, which can increase the chances that a student will struggle academically and socially or even drop out of school. Given diagrams as an imperative tool in the assessment process of learning gaps, senior secondary level Class XII students were given a picture-based questionnaire containing 16 original (real-life) images of biological entities and events; each of the images (microscopic and macroscopic) was followed by blank spaces for identification and labelling. The students were asked to identify the coloured images and write their responses. The student's responses highlighted the gaps and errors regarding the concerned topics that have formed over the years. It was followed by an open-ended interview to perceive the latent stimulus that drove the responses of the students for the images. The students' responses revealed some pioneering observations that subtly unveil the need for inclusion of the original (real-life) images in the science textbooks, in addition to the textbook images.
Keywords: Learning gaps, Original (Real-Life), Picture-based Questionnaire, Textbook Images

Introduction

"Mind the gap"is a frequently encountered visual warning phrase in the Indian metro railways that presages the passengers to carefully board the train to avoid any contretemps. The phrase has been employed to warn the travellers to avoid the gap between the train floor and the platform as they board or set off the train, thus, referring to the perils a gap can cause if unaddressed. In a similar genre, the authors tend to relate this phrase in association with the teaching-learning transactions of our schools where the students become victims of gaps in learning.

Fink (2003) has reflected upon one strategy for improving learning amongst students by integrating the new knowledge with the prior experience of the students. Teachers are responsible for guiding students to collate the old and new knowledge and facilitate them to analyse and synthesise at higher levels *(Bloom, 1956)*. Learning and its proper transmittance have always been the centre of debate for many educational psychologists. There is a distinction between meaningful and rote learning as stressed by *Ausubel et al. (1978)* who believed that the former refers to the reflection of personal understanding of what is being taught, while the latter denotes forced inputs of concepts into the memory to perform well in the assessment. Quoting *O'Brien (2008)* from her thesis (pp. 156–157), *"That is, subject matter that is construed, constructed and presented in instrumentalist, technical terms will facilitate largely instrumentalist, technically-oriented outcomes, effective for the mastery of key skills and competencies. In contrast, learning that requires the development of higher forms of knowledge and knowing, entailing a transformation of perspective and worldview, relies upon the construction of epistemologically more sophisticated views of subject matter and of learning."*It is quite evident that academic curricula with rigid and definite outcomes affect the quality of learning and that it impacts the cognition of the student. A child's concept development begins with an intermediate level of generality and gradually they understand the specific terms through differentiation and the generic terms through hierarchic integration *(Anglin, 1977)*. It is reported that a proper concept development requires active involvement of learners in knowledge construction (Driver, 1989). This can only be achieved through teachers acting as "Guides" in student-centered classrooms where the focus is on what the students are 'doing' *(Burnard, 1999*; O'Neill and Tim *McMahon, 2005)*. This brings us to one of the challenges faced by teachers—the vast premise of previous knowledge and varied competencies across students in a given classroom. Quoting *Entwistle (2008)* in a similar line, "Aiming at the average student no longer works well, because of these wider differences. Instead, strategies are needed to provide material in different ways that will suit students with different starting points and contrasting goals."In a study by Lawson (1983), it was observed that previous knowledge concerned with a given subject impacted the conceptual development and performance of the students in that subject. As a child progresses from lower to higher classes, he/she encounters the conceptual changes that come along the curriculum of senior classes. In that view, it is essential that the child builds an accuratecognitive framework in the junior classes so that it reinforces the integrity of past (academic) experience(s) to the future information (*Treagust and Duit, 2008*).

Motivation Of The Study

So far, we discussed the different facets pertaining to concept development, teaching-learning discourses, and the associated challenges. But this paper is concerned with the notion of learning gaps—an ideadisdained by the teachers, textbook designers, and curriculum experts whichrefrains students from fabricating their cognitive schemas for a given concept. Also referred to as conceptual gaps, learning gaps denote a learner's inadequacy of correct and complete information with regard to a given discipline. Dirksen (2013) has explicated the types of learning gaps into five categories based on their conception: Knowledge gaps, Skills gaps, Motivation gaps, Environmental gaps and Communication gaps. Of these, the authors are interestedin exploring knowledge gaps in biology learning that arose due to lack of exposure to completeand practical information. In a study, it was reported that such gaps can be conceptually exigent to the students, leading to misconceptions and deterring new information that eventually comes in advanced classes Jaewoo and Kun, (2005).One can argue on the different features of a 'good teacher', competencies and attributes of an 'effective educator' (Bernard Jr., 2015) but one can't deny that an obvious learning gap is a pervasive side-effect of the teaching-learning process, owing to the kind of delivery (of concept) by the teacher, textbook fallacies and the prevailing misconceptions within the students. Just as we started the paper with the notion of the warning at the metro stations, in many classes, the teachers are uncertain if their dialoguewith students is properly mediated, or how to ensure there is no learning gap(s) in dispensing the course content as pointed by Ginsberg (2010) when she said, *"Wecan mind the gap, but how do we get across it safely and effectively in the classroom?"*

In that view, let us try to shift our attention towards the idea of diagrams which are considered as crucial elements in students' comprehension of various ideas. Diagrams are considered a credible source of information because of their ability to map visuospatial aspects of the world to visuospatial characteristics of paper, providing visuospatial inferences (Tversky, 2001). Corter et al. (2009) have mentioned, *"Although they (diagrams) appear simple, especially to experts, beneath the surface they depend on simplifications, spatial analogies, and social conventions that are usually learned implicitly."* Diagrams foster an essential scientific skill of observation which is an initial point for studying scientific phenomenon (Johnston, 2009). But it is believed that learning from diagrams does not always happen as it seems; errors are commonly experienced even in the simplest of diagrams, the network of nodes and links (Corter et al., 2008)- the birth of a learning gap.

One of the ubiquitous tools used in the teaching-learning process is textbook, which is also a guide for the teachers and students Deshmukh and Deshmukh, (2009). Our Science textbooks lack in that original, or real-life images are majorly missing and instead schematic diagramsare given corresponding to the topics. Nevertheless these textbook images bear quite less resemblance to the real biological entity, thereby creating a perpetual 'learning gap' in the child regarding the concerned concept. In a study by Sangam and Jesiek (2014), it was revealed that textbooks can promote learning engagement among students and scaffolds the conceptual understanding, while theycan constrainlearning when misinterpreted and poorly conceived. But then the question arises—how to know if the students bear learning gaps? How to expose the source of the learning gaps so as to help students address them? Considering the research hitherto, the authors aimed to inspect the prevalence of learning gaps among the senior secondary students through a picture-based questionnaire,and investigate their sources through interviewing the students.

Research Methodology

Research design

The present study involved a picture-based questionnaire in a descriptive survey framework that intends to explore the learning gaps across the students taught concepts of biology. As discussed, the study aimed to elucidate the students' perception of the textbook images seen in their biology books and also frequently asked in examinations. Their perception will unravel the learning gaps that render the students to fail in procuring a good learning experience that they might not understand at the present stage, but surely realise its significance in the future discourse of their academic career.

Research tool(s) for data

The picture-based questionnaire was developed consisting of 11 questions (every question had a picture assigned to it) based on the different topics taught in Class XI Biology (NCERT syllabus) such as concepts borrowed from the *Chapter 3: Plant Kingdom, Chapter 4: Animal Kingdom, Chapter 5: Morphology of Flowering Plants, Chapter 6: Anatomy of Flowering Plants, Chapter 10: Cell Cycle and Cell Divisionand* so on. Students find the syllabus of Class XI biology conceptually challenging owing to the extensive number of chapters. In addition to that, these questions covered almost every aspect of senior secondary level biology concept(s) expected to be known to a Class XI student. Two questions were from Class XII Biology (NCERT syllabus) borrowed from *Chapter 2: Sexual Reproduction in Flowering Plants,* and it was ensured that the chapter was covered in the classroom before the study. All the pictures were original (real-life) images of biological entities and events that were already taught to the students and they were asked to identify the images and enlist their responses in the space provided corresponding to each image. The tool was validated by the concerned teachers to gauge its comprehensibility for the students, to which the teachers affirmed that the chosen pictures were the simplistic and easily deciphered ones for the given concept.

Research participants (Sample selection)

The study was conducted in Bhubaneswar, Khordha district of Odisha. A total of 53 students of Class XII (Biology stream) from a CBSE-affiliated (English medium) urban school participated in this study. The given school was easily accessible to the first author since he was working as an intern,and students were acquainted enough to give their consent for the study. The mean age of the students was 17.5 years (range 17–18 years). The majority of the students were females (39 of 53).This study did not focuson gender differences. All participants had been previously studying biology as a school subject from Class IX to XI which made the backgrounds of the students close to each other. Since this study was conducted during June–July 2016, all the Class XII students were taught Chapter 2 (Class XII textbook) as mentioned in the previous section.

Administration of the Study

The dates of the study were fixed in consultation with the principal of the school. Three days before the picture-based exercise, the authors interacted with the students and the students were advised to browse through the figures (as is referred) of different chapters given in their Class XI biology textbook and whatever recently covered in Chapter 12. It was told to the students that there are no assessment tests but it is a simple survey for our understanding of the teaching-learning process practised in their school.

On the study day for the picture-based exercise, each student received two sheets—one with the questions (Supplementary material #1) and one with the colored images (Supplementary material #2). The latter sheet comprised blank spaces corresponding to every image for the students to write their responses. At the same time, the students were given the following instructions: "we would like each of you to consult the questionnaire (Supplementary material #1) and write your responses in the picture sheet (Supplementary material #2). You will be given 35 minutes, that is, one periodtocomplete this activity. You can write your name only if you wish, but please mention your gender. This is not an examination, so there will be no assessment but it is a part of our study which involves students of your age."

In addition to the above, to glean the reason behind students' responses, the study employed an open-ended interview after examining the responses. The questions in the interview were meant to investigate the difficulties that the students encountered while identifying the images. The questions aimed at inspecting the source from which students were taught the diagrams and what were their difficulties in answering the exercise questions.

3.5: Data Analysis

The answers of the students were analysed in three categories, broadly as correct responses (I), close to correct responses (II) and incorrect responses (III). Certainly, the responses close to correct (II) and incorrect responses (III) signified the potential learning gaps among the students. So, it was further analysed for its frequency in view of the kind of the images—in other words, if the macroscopic biological units witnessed more learning gaps or the microscopic ones. The unresponsive images were considered as inability by the students to intuit the images and therefore, can be labelled as a "learning gap". This supposition was verified during the interview when the students accepted that they were unable to infer the images as they have seen them for the first time or they were unable to relate them with any textbook diagrams. The statistical analysis of the responses was performed through PAST 4.0 which is a free software for scientific data analysis, with functions for data manipulation, plotting, univariate and multivariate statistics.

Results

Comprehensive analysis of Student Responses

“Students’ learning engagement is an appropriate predictor of students’ behaviour in the teaching-learning process and is an essential requirement for assuring the quality of education and achieving the desired learning outcomes”(Sumaiya and Masih, 2016). In the given paper, the authors endeavoured to interpret the students’ behaviour through their responses. In Figure 1, the responses of the students are modelled through neighbour-joining method wherein the two nodes are originating from (a), namely (b) and (c) where (b) branches further to (d) and (e) and (c) represents ‘no’ responses. The two nodes (d) and (e) are linked to the common ancestral node (b) which represents responses. (d) ends with the ‘close to correct’ responses and (e) terminates with branches (f) and (g) where they represent ‘incorrect’ responsesand ‘correct’ responses respectively.The normal probability plot as shown in Figure 2 confirmed that the data set(s) is approximately normally distributed with tailing due to outliers at the extremes. The *Shapiro-Wilk W* for the given data set is 0.9247 (which is greater than α=0.05) and therefore accepts the null hypothesis (Data sets are normally distributed).

The authors have detailed the learning gaps of the students byanalysing their responses.The responses of the students are

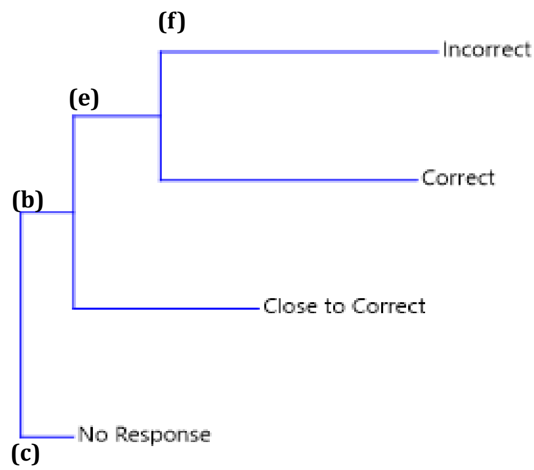

Figure 1. Neighbour-joining Model for Interpreting Students’ Responses

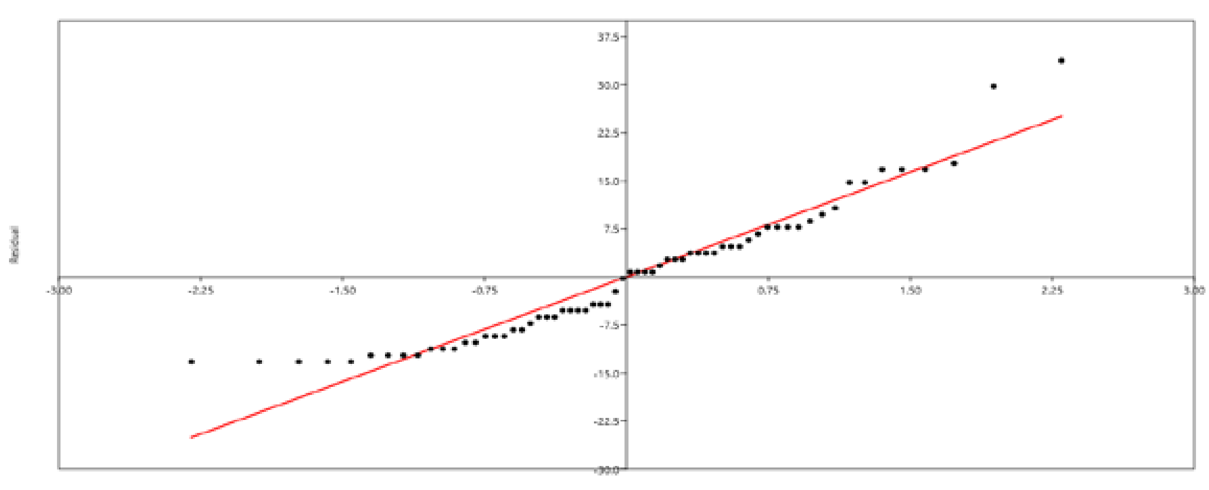

Figure 2.Normal Probability Plot for the Data Set of the Study

graphically depicted in Figure3 that provides a comparative notion of the learning gaps with respect to the questions.

Analysis of the Learning Gaps

The highest number of “incorrect responses” (47; 92.157 per cent) was found for the 4th

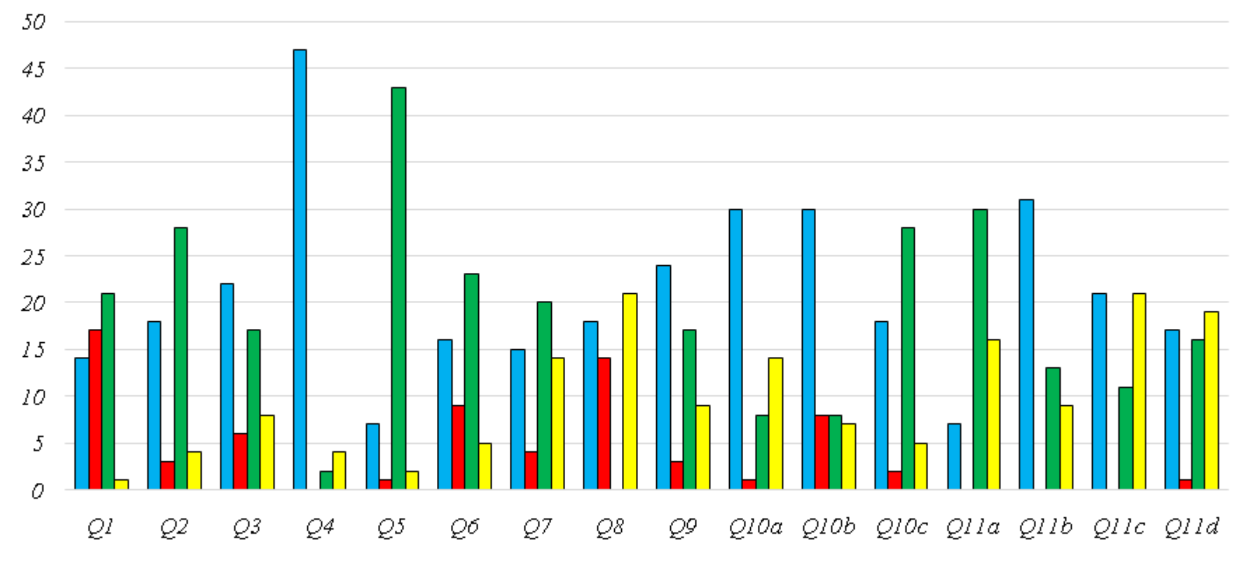

Figure3. Comprehensive Graphical Representation of the Students' Responses

Inrelation to the given figure, Table 1 depicts a detailed understanding of the learning gaps among senior secondary students. The “Close to Correct” responses reflect the vulnerability of the students to imbibe a learning gap while “incorrect” responses show the number of students with learning gaps. The higher number of “incorrect” responses in the questions dealing with aestivation and placentation can be attributed to the fact that they might have crossed the tests through the textbook concepts but unable to relate the learning outcomes with real-life experiences due to learning gaps. The highest number of “correct” responses in the 5th question (Anther TS) signified that the students could understand the given image and relate to what they have learnt in the classes.

Table 1: Learning Gaps of Senior Secondary Students after Analysis of Responses of the Picture-based Questionnaire

Question	Correct Answer	No. of correct responses	No. of close to correct responses					No. of incorrect response							No. of no responses
1	Angiospermic Ovule	21	Egg cell (1)	Embryo (9)	Ovule development (4)	Female gametophyte (2)	Ovary development (1)	Brain/ Brain Tumours (11)	Microsporangia (1)	Skull (1)	Neuron (1)	-	-	-	1
2	Sponge	28	Benthic specimen (1)	Ocean creature (1)	Aquatic animal (1)	-	-	Corals (18)	-	-	-				4
3	Metaphase	17	Cell division (3)	Mitosis (2)	Chromosome (1)	-	-	Cytokinesis/ Cell/ Nucleus (5)	Testis/ Sertoli cells (9)	Cell diffusion (4)	Pollen (1)	Fibres (1)	Inner Brain (1)	Ovum (1)	8
4	Leaf TS	2	-	-	-	-	-	Stem TS (25)	Root TS (5)	Vascular bundles (12)	Periderm (2)	Wood Cell (1)	Plant Cell (2)	-	4
5	Anther	43	Microsporangia (1)	-	-	-	-	Spores (1)	Tapetum (1)	MMC (1)	Pollen grains (1)	Group of cells (1)	Gametophyte (1)	Sporophyte (1)	2
6	Nereis	23	Annelids (1)	Annelida: *Dero*(5)	Worm (3)	-	-	Millipede (7)	Centipede/ Kankhajura (2)	Earthworm (3)	Spine worm (1)	Dangerous worm (1)	Aquatic animal (1)	Ear worm (1)	5
7	Chloroplast	20	Green Pigment of leaves (4)	-	-	-	-	Watermelon (8)	Stomata (2)	Leaf TS (1)	Seed locule (1)	Green cells/ strands (3)	-	-	14
8	Ciliated Columnar tissue	0	Epithelium (4)	Columnar (10)	-	-	-	Testis TS (4)	Germ cells (1)	Cells/ Layer of cells (3)	Saliva/ Cheek/ Hair cells (3)	Multicellular (1)	Plant Epidermis/ Petiole/ Fruit pulp (3)	Stained/ Pink/ Mammalian cells (3)	21

9	Funar-ia	17	Sporo-phyte (2)	Moss (1)	-	-	-	*Anthoc-eros* (6)	Seed germi-nation/ Gram (3)	Plant speci-men (2)	*Tridax* (4)	Algae (1)	Gym-no-sperm (6)	Liver-worts (2)	9
10 (a)	Pari-etal	8	Placenta linked seeds and fruit wall (1)	-	-	-	-	-	Cucum-ber (7)	Cen-tral/ Free Central (12)	Placen-tation (5)	Axile (3)	No. of ovules (1)	Bottle Guard (2)	14
10 (b)	Axile	8	Axial (7)	Five ovules with placenta linking seed and fruit axis (1)	-	-	-	-	Lady Finger (14)	Pen-talocu-lar (11)	Placen-tation (1)	Basal (1)	Pari-etal (1)	Free Central (2)	7
10 (c)	Mar-ginal	28	Ovules at the mar-gin of the fruit (1)	Ten ovules at the edge (1)	-	-	-	-	Pea (14)	Placen-tation (1)	Axile (1)	Placen-ta (1)	Basal (1)	-	5
11 (a)	Valvate	30	-	-	-	-	-	-	Penta-petalous (2)	Quin-cuncial (2)	Normal (1)	Flower (1)	Vex-illary (1)	-	16
11 (b)	Twist-ed	13	-	-	-	-	-	-	Penta-petalous (2)	Imbri-cate (8)	Valvate (11)	Hibis-cus (10)	-	-	9
11 (c)	Imbri-cate	11	-	-	-	-	-	-	Penta-petalous (2)	Quin-cuncial (1)	Twisted (13)	Vexil-lary (3)	Valvate (2)	-	21
11 (d)	Vexil-lary	16	Keel (1)	-	-	-	-	-	Dipe-talous (1)	Imbri-cate (13)	Incom-plete flower (1)	Valvate (2)	-	-	19

Note: The number in parentheses depicts the frequency of students for the given response .

question which was meant to identify the transverse section of a dicot leaf. We have detailed the responses and found that students are getting confused between the transverse sections of other vegetative parts of the plants like stems (25; 49.020 per cent), roots (5; 9.804 per cent), vascular bundles (12; 23.529 per cent) and other parts (5; 9.804 per cent) as shown in Table. 1.The 'incorrect' responses are the unheard echoes of learning gaps present in the cognitive schema of the given respondents. For the 11th question, the persistent occurrence of the term 'pentapetalous' and'dipetalous' signified that the students are using their observation skills after witnessing the pictures and scientific reasoning to answer the questions,validating the importance of real-life pictures in science education. The pictures given in their textbook with respect to the given concepts are distinctively different from the real-life images and that must be the underlying confusion in the responses—students marked quincuncial (2; 3.77 per cent) and vexillary (1; 1.89 per cent) for valvate (Q11, a); imbricate (8; 15.09 per cent) and valvate (11; 20.75 per cent) for twisted (Q11, b); quincuncial (1; 1.89 per cent), twisted (13; 24.53 per cent), vexillary (3; 5.66per cent) and valvate (2; 3.77 per cent) for imbricate, etc. In a similar line, the "incorrectresponses" can be explained for the 10th question where the learning gaps befuddled the students to ascribe the correct "placentation" to the right picture. In this question, many students reported their responses as "cucumber", "bottle guard", "lady finger" and "pea". This concludes that the students simply couldn't apply their theoretical understanding of "placentation" to the real-life experiences due to practical unfamiliarity with the concept. An interesting observation lay with question 2 portraying the picture of a "sponge" where 18 (33.96 per cent) students mentioned it as a "coral", the authors believed that the students wouldn't have committed this mistake if they were shown a real-life image of these specimens while the chapter was taught or if the textbook contained it.

The "close to correct"responses indicated that the students know the answer toa given question but the learning gaps impeded them to write the correct answer. For example, the 1st question representing angiospermic ovule got 17 such "close to correct" responses like egg cell (1; 1.89 per cent), embryo (9; 16.98 per cent), ovule development (4; 7.55 per cent), female gametophyte (2; 3.77 per cent) and ovary development (1; 1.89 per cent). All these responses are proximal to the correct answer but unfamiliarity with the real-life image of an ovule caused the learning gap. Similarly, the 6th question of Nereis received 9"close to correct" responses wherein the students mentioned Annelids (1; 1.89 per cent), Annelida: Dero (5; 9.804 per cent) and Worm (3; 5.66 per cent). It is clear that students tend to identify the picture correctly but the learning gap occupying their cognitive space caused the mistake. The "close to correct" responses that came from Q3 (Metaphase) also indicated similar notion where the respondents provided answers like cell division (3; 5.66 per cent), mitosis (2; 3.77 per cent) and chromosome (1; 1.89 per cent). All these responses were close to the right answer but scientifically erroneous for the given picture-question. It is also observed that"close to correct" responses are more for the two microscopic concepts—Q1: Ovule 17 (32.08 per cent),Q8: Ciliated columnar tissue 14 (26.42 per cent)—if analysed individually. The authors conclude that real-life images should be stressed for the microscopic biological entities since they tend to help clear the confusion with the textbook images.

Qualitative analysis of the Interview

Owing to their acquaintance with the first author of this study,all the students mentioned their names in the exercise sheet. The rounds of interview were conducted as a later part of the study where only selected students (who expressed the possession of learning gaps) were interviewed in an amiable classroom environment. It was observed that the highest number of "no responses"

(21; 41.176 per cent) were found for Q8 and Q11(c) which were associated with the transverse section of ciliated columnar epithelial tissue and a flower with imbricate aestivation respectively.In the interview, it was found that the inability of the students to respond to the said questions were primarily because of two reasons: "seen something like this but can't find a resemblance to the textbook diagram" [31.373 per cent for Q11 (c)] and "never seen such an image and saw it for the first time in questionnaire" (23.529 per cent for Q8) (see Figure 4). The highest number of "correct responses" (43; 84.314 per cent) was observed for Q5 which can be attributed to the fact that the question belonged from Chapter 2 of their Class XII textbook, which has been taught practically and the slide preparation of transverse section of the anther(s) was a part of their lab exercise. There is a trend observed in the correct responses of Q10 (a, b, c) and Q11 (a, b, c, d) which can be ascribed with a reason: for Q10 (a, b), the number of correct responses is considerably lower than that of Q10 (c). When asked during the interview, the students informed that while teaching the topic in class, the teacher happened to collect a "pair of pea pods"from the school garden and showed that as an example of "marginal placentation"while no such teaching practice was exercised for the former two.

For Q11 (a, b, c, d), the number of correct responses was much higher in Q11 (a) than the rest of the sub-questions; when the authors tried to find the reason

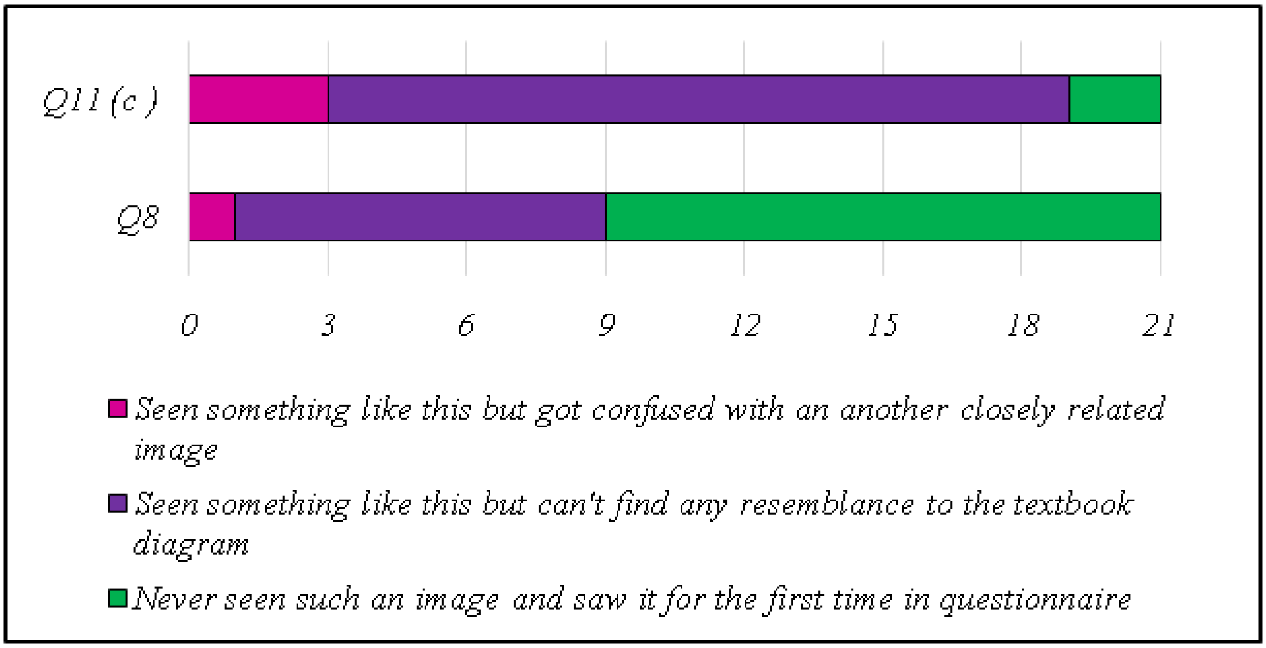

Figure 4. Qualitative Assessment of Interview Reactions for 'No' Responses

through interview, the students recollected that the teacher showed them the flower of "Periwinkle"while taking the class on "aestivation"and pointed the flower as an example of "valvate"aestivation, which was not done for other kinds of "aestivation". While conducting the interviews, the authors observed that students tend to believe in their learning gaps since they relate it to their experiences and if unattended, the students consider that as valid information. For example, Q9 was meant for identification of *Funaria* where we noticed that few students (3; 5.882 per cent) wrote seed germination as an answer. When asked in the interview, the students admitted that they have spotted gram sprouts and the given image looks a lot like that. Similar learning gaps were witnessed for Q6 (16; 30.19per cent "incorrect" responses) which was associated with an image of *Nereis*. 7 (13.21per cent) students labelled it as millipede, 2 (3.77per cent) students labelled it as centipede (one student wrote *Kankhajura* which means centipede in Hindi), 3 (5.66percent) students labelled it as earthworm. In the interview, the students replied that they associated the image with what they have experienced around them with similar morphological features and accordingly answered the question.In the 8th question (Ciliated columnar epithelium T.S.), 4 (7.55 per cent) students mentioned it as the image of Testis T.S. while 3 (5.66 per cent) students marked it as cells of saliva/cheek/hair, etc. In the interview, the studentsconsensually agreed that these structures are closely related and the textbook images tend to be similar- here, the role of the teacher becomes impeccable to provide the students with real-life images to avert such misconceptions.When we interviewed the 47 students who responded incorrectly for the 4th question (maximum incorrect responses), we found that more than 80 per cent students (39) reported that they were very confused with the transverse section(s) of plant parts, as the textbook was filled with many images and they never saw a real-life image or specimen of the same. In the interview, 18 (33.96 per cent) students reported for the second question (sponge) that they have seen structures similar to the questionnaire in National Geographic shows. They couldn't differentiate between a coral and a sponge since they believed both were synonymous due to resemblance in their structures. They further added that the textbook contained a figure of sponge but not of a coral, and the teacher never showed any image of the biological species.

Discussion

"The vision of NCF 2005 to reorient the perception towards 'learners and learning' and to follow a holistic approach towards their development seems to have been realised only partially" Sumaiya and Masih, (2018). According to the framework, experiential learning is practiced in a classroom in which a teacher would act as a facilitator, encouraging students' creativity and students would actively engage themselves in the process of knowledge construction. Presentation of information by textbooks and teachers is consociated with the birth of misconceptions Barrass, (1984) and our findings strongly support the given notion. All the students affirmed that neither any real-life images were shown to them nor any hands-on activities (practical classes) were conducted. The authors also found that textbook illustrations are a hidden impetus to the development of learning gaps as was reported by Buckley (2000). Our textbooks includeschematic diagramsof the biological concepts which fail to replicate the features of the original (real-life) phenomenon/ entity, thus, proffering the developing minds to conceive the learning gaps. Images are considered to be a decisive mediumof (transformative) information transmission which can cause learning difficulties if they do not reinforce with previous ideas of the students Colin et al., (2002). Though the authors hypothesised that there will be a distinct difference between the correct responses for the questions with macroscopic images and questions with microscopic images but no such notable variations were recorded. In addition to that, the authors couldnot trace a specific pattern in the learning gaps of the macroscopic and microscopic concepts. This could be because eachstudenthas a unique style of learning and reception of information. Yip (1998) and Dikmenli and Cardak (2004) evaluated science teachers' knowledge on circulatory systems and they found that most teachers were unable to relate different concepts pertaining to the said topic. Through the interviews, the authors also realised that there was a lack of subject competence in the teachers, particularly when the students mentioned, "We asked for some examples on Valvate aestivation apart from the Periwinkle flower, but Ma'am said this is the only example along with the one mentioned in the book! So, write these names in the exam!" It has been pointed out by Colin et al. (2002) that teachers are far from agreement when they were informed about the difficulties faced by the students. Though we did not explore the teacher's view but the occurrence of "incorrect" and "close to correct" responses in high frequency can be predicted as a result of teachers' lack of awareness towards the students' learning gaps.

The authors accept that it may not be practically possible for the teachers to provide hands-on activities for every chapter in biology but they can at least fetch help from ICT-based teaching aids to familiarise students with the original (real-life) images of the biological concepts. Posner et al. (1982) elaborated conceptual change based on the theory of constructivism and termed it as the process where learners comprehend and accept ideas because those are perceived as intelligible and rational by the learners. Therefore, the authors support their findings and convey to the members of the textbook development committee, curriculum developers and teachers to consider the importance of original (real-life) biological images for an unerring delivery of the subject content (Supplementary material #3). In addition to that, the authors also propose picture-based questionnaires as a plausible assessment practice for diagnosing learning gaps among students.

6. Implications

In the context of Indian education, this paper can be used as a baseline study to ratify similar research efforts in different disciplines of science and social sciences. The implications of the paper can be as follows:

a. Creating the lesson plan such that students can be madeaware of the real-life images through visual aids or hands-on activities.
b. Helping teachers to design an assessment framework to identify the learning gaps and eventually address them.
c. Exploring the learning gaps of students through the lens of gender.

7. Conclusion

The study investigated the learning gaps of senior secondary students in biological conceptsand concluded that use of original (real-life) biological images as an epistemic practice at least in biology. Images play a pivotal role in supporting the teaching-learning practicesand visually stimulate the students to observe and relate the theoretical takeaways with the practical world. Observation is the basic scientific attribute that paves the way for higher scientific skills, like interpretation of data and deducing a conclusion. Therefore, a learning gap in the understanding of textbook images will eventually encumber their observation and ability to relate to the real-life biological phenomenon, thus negatively affecting the higher order scientific skills. A student-centric delivery of information in a classroom can be a remedy when the teachers mind the gap between what her/his students know and what she/he wants to teach them (Barr and Tagg, 1995). As stressed by Janosz (2012), education needs to emphasise on transforming the learners from 'passive absorbers of knowledge'to 'active constructors of meaning', and our findings tend to support this assertion. With the given goals in mind, the next step is to consider how to scaffold this study for other disciplines of science and how can teachers provide enough help that the students achieve a complete understanding, eliminating the learning gaps. We recognise the inclusion of original (real-life) images as a scientific practice in order to maximise the students' understanding of biological sciences.

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