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Combining Diverse Pedagogical Tools for Effective Teaching of General Biology to a Large Class Comprising of First Year Science and Engineering Undergraduates

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ABSTRACT

Getting students interested in learning science and opting for a science-based career has always been a dream, despite the associated challenges in the form of dropout and attenuated student interest, for the university teacher. Secondly, in college or university academic curriculum, large classes often become a necessity to ensure uniformity in concept delivery. As a consequence, the best teacher strives to become something akin to an all-rounder, where the huge diversity concomitant with large crowds (classes) needs to be addressed to succeed. The present work was carried out to tackle the above challenges by introducing certain innovations in the teaching methodology. In the present study, the author experimented with the different fields from which analogies could be picked up to deliver relevant biological concepts; other pedagogical tools used were variety in language usage; student-teacher distance; colourful and pictorial slides with least text, musical concept summaries, drama, story, humor; interruption in lecture delivery was often done by asking questions of higher Bloom's taxonomy levels from the students, and allowing them time for peer discussion. Clapping for correct answers was encouraged to break the monotony of sitting sedentarily in class. Analogy pertaining to a real life inspiring figure was deemed the most effective by student community. Among other pedagogical tools, questions from previous years' exam papers were most effective. It was also realized that timing of the non-academic element (such as story or music) was important for effective lectures. The present study, although simple and small in scale, could help guide further classroom innovations where introduction of variety in the traditional lecture mode in biology (science) classes is the ultimate goal.

Keywords: Science education, general biology, pedagogical tools, large classrooms, analogy, active learning

In today's times of economic liberalization, sustaining the interest (and enrolment) of students in science-based careers is a big challenge and many of them often drift out to other more professional courses (Garg & Gupta, 2003). In this perspective, motivating students towards science becomes an important goal for any science teacher. Besides, the current advances in the field of education, heralded by a boom in information technology, have challenged the role of school- and college-instructor like never before. Today the teacher is expected to be not only a master of (ever-increasing) content but also that of delivery, otherwise he/she may be faced with plummeting student attendance, attention and appreciation (Seymour & Hewitt, 1997). The choice available to the modern student has increased tremendously, thanks to the online or video lectures on the same topic available via the internet, delivered by masters of the art. The situation becomes more challenging if biology or life sciences, a subject bearing a notorious tag of testing the human memory to extremes, is to be taught to formulae-savvy college freshmen, oriented towards a career in engineering.

Thereupon arises the urgent need for the biology instructor to rescue himself/herself and his subject alike lest his audience revolt or vanish. In context of nursing education, Bradshaw & Huldquist (2016)

have pointed out that faculty should make an effort to introduce variety in their teaching style, rather than the conventional "information telling" approach. To an extent, the student population can contribute to the teacher's "variety style" and aid in the overall teaching-learning process. Again, it is important to note that today, the field of education is moving from passive into an "active learning" mode (from the perspective of students), and it is increasingly being recognized that a good teacher is one who is able to stimulate discussion among students (Wood, 2009). Of course, this is challenging in the large class scenario; however, as pointed out by Daniel (2016), even small scale changes in classroom strategies (including collaborative learning as happens during discussion over a problem) can have large impacts on student learning outcomes. Therefore, if the instructor can balance the "variety" element in pedagogy with "students' active learning", the overall impact is enhanced. It is pertinent to note here that at times, large classes become a necessity, either due to the administration's requirement of uniformity in lectures delivered or due to the demands of the existing student-teacher ratio.

All the students of Birla Institute of Technology and Science (BITS), Pilani, India, irrespective of discipline, are required to take the science course, General Biology (BIO F111), in their first year, first semester (http://www.bits-pilani.ac.in/integratedFirstDegreeOverview). Similar courses are offered in many university curricula all over the world. The challenge level for the instructor at BITS is great because more than 90% students did not study biology in their (post-secondary) 11^{th} & 12^{th} standards, and most of them would be choosing to make their career in engineering streams – either through direct admission or through the unique facility of opting for a dual degree offered by the institute. *Secondly*, the specific challenges in learning biochemistry involve remembering names of complex biochemical pathways and enzymes; apart from formulae and structures of biomolecules. The challenges in learning cell biology include memorizing names along with diagrams of different cellular substructures (the organelles). *Thirdly*, the conventional thinking about learning biology is that it is mainly rote learning, involving the memorizing of names of organisms, etc., with little conceptual thinking involved. *Fourthly*, the class strength in General Biology lectures is large – around 200-450 students (the number varies as attendance is not compulsory, and usually decays as the semester progresses). This presents a challenge for the instructor as the communication in class is often one way – only the instructor is speaking – and the students tend to become passive or restless as the class proceeds. It is a well-recognized fact that today, irrespective of class strength, the full 50 minute class taken in the lecturing mode is no longer acceptable in the student community, who are from diverse backgrounds, inclinations and capabilities (Catherine, 2010).

All the above parameters – student background and interest, complexity of the subject, convention and large class strength – present not only a challenge but also a great opportunity for the instructor of large lecture classes in general, and General Biology in particular, to experiment with new pedagogical tools for effective classes. The use of stories and analogies in effective teaching of biology has recently been brought out very well by Parker (2016), who has built a story around cell organelles, tagging them as a 'loose confederation of employees'. The real challenge is: how to design analogies/stories and in what sequence to use these and other tools during the lecture so that not only the class is made interesting but the concepts are not compromised. The present paper is the author's attempt towards the same. The author wishes to clarify here that the analogies are a matter of subjective taste and is only giving here a few guidelines, rather than limiting the range of analogies to be chosen for classes. Other pedagogical tools used were music, questioning, teacher movement, etc, designed with the purpose of adding variety in delivery, breaking class monotony and facilitating effective learning. Effectiveness of each of the tools used is discussed in the current paper.

METHODS

General Biology course offered at BITS, Pilani-Pilani Campus has two lecture sections. Using different pedagogical tools, the author delivered the lectures for lecture section 1 (around 450 students). The content corresponded to the biochemistry and cell biology portions of the course, spread over twelve lectures of fifty minutes each. It was arranged to

provide the lecture power point slides (at times selected slides only, those containing information not present in the textbook) to the students after every class, so that they could focus completely on the lecture, without having to bother about taking detailed class notes when the lecture was going on. The class strength was variable (as attendance is not compulsory in BITS) and varied in the range of 200-450 students, belonging to different academic backgrounds and discipline.

The effectiveness of the pedagogical tools was assessed through a questionnaire distributed to each student after the lecture series was over and the results were analyzed. On that particular day, 245 students attended the class and filled the questionnaire.

Designing Analogies

In order to reach the mind of every possible type constituting the class, analogies were chosen from the popular topics in cinema, religion, literature, video game and day-to-day observation. Specific care was taken to make the analogies revolve around relevant social issues or contemporary superheroes and other popular figures from Hindi/English movies or motivating heroes from real life or figures from mythology, so that the maximum possible attention of the students was gained before the main topic in biology was delivered.

Using other Pedagogical Tools

Other pedagogical tools used in the class included variation in language (use of Hindi as a second language besides English as the primary one), music (youthful and theme-based, capturing the essence of the lecture topic or coinciding with a concurrent festival), movement among students (to connect with maximum population) and telling inspiring quotes and humorous anecdotes. The students were also given questions from previous year's exam papers and asked to solve the same after reflection and mutual peer discussion; thereafter, one of them would voluntarily explain (on the microphone) the correct answer; everyone was asked to clap loudly (thereby breaking the passivity of sitting silently in class with least movement).

Setting the Sequence for the Pedagogical Tools

Sequencing i.e. timing of the pedagogical tools in the lecture is important to be effective. In the past the author has experimented with many sequences and found the following to be most effective (from personal observation and student feedback): Beginning the class with an inspiring quote displayed on the projector screen (often discussed briefly for a minute or two before commencing with actual lecture) → Giving students two minutes to recall/discuss among themselves the important concepts learnt in the previous class (thereby making the students immediately attentive) → Asking one student randomly to speak out the same → Appreciating the answer if correct and clapping for encouragement, allowing other students to do the same → Discussing the learning objectives of the day → Relating (using appropriate voice modulation to bring in an element of drama) a relevant analogy/story before introducing the main concept (This allows the students to listen at a deep level and makes them receptive to take in further material more enthusiastically) → Discussing the concept using power point slides (mainly pictorial with less text) and/or appropriate videos provided by the publisher (8-10 minutes duration) → Asking a conceptual question (Bloom's level 3 and above) to gauge if the students have understood the concept, giving time for discussion among themselves, then encouraging one of them to explain to the whole class, followed by clapping as above → Summarizing the concepts at the end of the class using power point slides with music playing in the background.

RESULTS

Nonscience is defined as 'something (as a discipline) that is not science' by the Merriam-Webster dictionary. According to Enger *et al.* (2012), non-science includes art, literature, theology and philosophy, with each being a respectable field of study. However, these may serve as valuable resources for picking up analogies from (Glynn, 1994). Also, for effective retention of the concepts by students, analogies are important if delivered in a social context which the students can relate to, e.g. specific culture to which the latter belong (Chamany *et al.*, 2008). It is an undoubted fact that the teacher would have to read a lot (or be aware of happenings around) and jot down relevant analogies whenever possible for use in class. It should also be borne in mind

that the an effective and relatable analogy should simply introduce the more difficult concepts to the students, and in no way aim to replace the latter.

In the current study, anecdote involving a known figure, who was also popular in his own particular field (such as Henry Ford), was found to be very effective in drawing attention of the class (Table 1). 67% students found this analogy very effective. From this study, it was expected to have an idea about the area from which relevant analogy, if picked up, would be more successful than others in achieving student connect. It was found that examples picked up from the areas of cinema, management and general observation were more effective when compared to literature and spirituality. For example, only 27% students chose the 'very effective' category for the analogy of a 'Buddhist Samsara Chakra' to a cyclic metabolic pathway (wherein a key substrate in a biochemical pathway in an organism is regenerated at the end of the cycle).

An effective teacher maintains a lot of variety in his/her teaching style, thereby avoiding boredom and aiding learning/attentiveness. This might also require the teacher to execute a bit of drama before the class; of course, a teacher at undergraduate level must rise above the commonly prevalent idea that college level teaching must be more serious and less fun. Therefore, besides analogy, a number of other pedagogical tools were used in the study including language variation, music, movement among students, inspiring quotes, questioning (followed by peer discussion) and humour. Table 2 presents the results obtained. In the present study, it was seen that discussing questions from previous year's papers was most valuable (91% students found this very effective), followed by teacher movement (73%), music and inspiring quotes (69%), language variation (67%) and humour (61%). A high percentage in the first case could also point to the fact that students are highly interested in scoring marks besides learning the subject. Therefore, including questions from previous years' papers assumes significance in the instructor's teaching strategy.

DISCUSSION

The prospect of teaching large classes at college and university levels often tests the most experienced teachers as it demands more preparation (not only content-wise but also presentation-wise) and patience in the midst of research and administrative tasks. Add to this the modern student's expectations to engage in active learning rather than to be just a passive listener. Therefore, the teacher has to introduce other elements, besides continuous information delivery, into his/her teaching methodology to keep the class focused and alive. Some of these elements include interrupting periods of a standard lecture class with story, discussion, music, humour, movement, language variation and last but not the least, a feasible physical activity by students such as clapping.

Story or anecdote appeals to the deeper levels of human consciousness, and the listener becomes receptive to hear what comes next. Concept delivery to student may include not just the final facts, but also how the concerned scientist/inventor arrived at the same including his/her struggles and setbacks. This itself could form an interesting story to be shared with the student community and inspire them towards a career in science (Chamany *et al.*, 2008).

Tradition demands silence in class. However, this enforced silence may need to be sacrificed if the students are to engage in discussion to arrive at solutions to specific problems. Lemke (1990) has stressed on giving students more practice talking science rather than plain listening. Questioning the students on the concept just taught, and also allowing in some cases a few minutes of discussion with the immediate neighbor, is another method to make the student more comfortable and less passive in class, and actively arrive at answers via discussion and 'think-pair-share' (Wood, 2009; Angelo & Cross, 1993). In order to encourage discussion, it is important that questions be designed keeping in mind the Bloom's taxonomy level 3 and above (which test for student's skills in application, analysis, synthesis and evaluation) (Bloom & Krathwohl, 1956). Instead of asking for plain definitions, students have to be given real life problems to solve (which can be obtained from nearby industries). Also, in the current study, if a student answered a posed question correctly, others were encouraged to clap as a token of appreciation for the 'bold one'. One incentive given by the author to encourage clapping was that it improved

Table 1: Results of the objective student feedback obtained through questionnaire analysis on effectiveness of the different analogies used

Sl. No.	Field of biology	Scientific Concept Discussed	Analogy used	Field of non-science from which the analogy was picked up	Can't Say (%)	Not Effective (%)	Effective (%)	Very Effective (%)
1	Biochemistry	Tensile strength of spider silk protein	Spiderman bringing a train to halt in the movie 'Spiderman-2'	Cinema	2	2	44	52
2	Cell Biology	The movement of phospholipids in cell membranes	The whirling dance of Sufi dervishes	Spirituality	9	32	39	20
3	Biochemistry	Function of important classes of biomolecules in cells	Riddle-like statements given by the saint Kabir referred to as Kabir's ulatbansis	Spirituality	10	22	43	25
4	Cell Biology	Function specialization by cell organelles	Henry Ford's concept of assembly line for car manufacture	Management	3	5	25	67
5	Cell Biology	Interconversion of cell membranes during endocytosis/ exocytosis	Harry Potter's entering the platform 9 ¾ from J.K. Rowling's novel	Literature/Cinema	9	18	39	34
6	Cell Biology	Amphipathic nature of phospholipids in cell membranes	Robert Louis Stevenson's story 'Dr. Jekyll and Mr. Hyde'	Literature	15	13	37	35
7	Biochemistry	A cyclic metabolic pathway such as Kreb's cycle or Calvin cycle	The 'samsara chakra' in Buddhist religion	Spirituality	11	21	41	27
8	Biochemistry	The role of coenzymes during cellular respiration	Holding of Ganges water by the Hindu god Shiva in his dreadlocks	Mythology	6	11	40	43
9	Biochemistry	The way cyanide inhibits oxidative phosphorylation in cells	A criminal consuming cyanide to escape being caught by police as shown often in Hindi movies	Cinema	10	10	33	47
10	Biochemistry	Photons of light falling on photosynthetic antenna complex	Game of dart	Sports	8	9	41	42
11	Biochemistry	The role of the accessory pigments in leaves during photosynthesis	O. Henry's short story 'The Last Leaf'	Literature	6	17	33	44
12	Biochemistry	DNA repair via proofreading	The Buddhist saint Milarepa atoning for sins committed in the past	Spirituality	14	16	39	31
13	Biochemistry	The way organelles slide over microtubules or DNA polymerase over template DNA	The Subway Surfer moving on railway track in the popular game	Video game	6	19	40	35
14	Biochemistry	Role of tRNA in protein synthesis (translation)	The job performed by a coolie in railway stations	General observation	3	6	35	56

Table 2: Results of the objective student feedback obtained through questionnaire analysis on effectiveness of the different pedagogical tools used

Parameter	Pedagogical Tool used	Can't Say (%)	Not Effective (%)	Effective (%)	Very Effective (%)
Language variation	Using Hindi language along with English while delivery	3	5	25	67
Music	Playing of popular theme music from movies or soft classical music during presentation of concept summary	2	8	21	69
Teacher Movement	Movement of the instructor in between students (so as to reduce the teacher-student distance)	0	2	25	73
Inspiration	Inspiring quote by a famous personality flashed on screen for contemplation at the beginning of lecture	3	4	24	69
Questions and discussion	Flashing questions from previous years' exam papers/other sources and subsequent peer discussion	1	1	7	91
Fun or humour	Using humour / funny comments from time to time	4	6	29	61

health by pressing the key acupressure points. A good teacher is one who helps in the dissolution of inherent fear in the students about speaking in class or making some sound, and this activity hits bull's eye in this regard.

Language variation is an important tool the instructor has, to break the monotony in his/her lecture delivery. Use of the mother tongue helps to break barriers and strike a chord with the listener. However, care has to be taken that if an important concept has been delivered in a particular language, it is repeated in the universally understood language (viz. English), as many students may be from (non-native) non-Hindi speaking backgrounds. The author kept this in mind during his lectures at BITS, Pilani.

The use of music in large undergraduate classrooms relaxes the atmosphere, and if used effectively, serves to raise concentration levels. According to Crowther (2012), the mechanisms by which music might impact learning include enhancement of recall, reduction of stress, multi-modality delivery, increased enjoyment and in-depth exploration of content. The choice of music to be played – from mainstream cinema or science-based songs - is an important consideration in this regard. It is better if it is a soft and/or popular piece so that students are not unnecessarily excited and damage the class decorum in doing so. In the present case, music was played in the background at the end of the lecture, while important summary points of that day's lecture kept flashing on the LCD screen. Classical instrumental music or soft theme music from current movies was played. Music-enhanced concept summary at the end of the lecture enabled the instructor in the current course to end the class, more often than not, with a little drama and awe.

When the instructor does not simply stand at the dais but moves among students, first and foremost, the communication is better as the distance between the teacher and the student is minimized. This is especially important in large classes, where students at the back might feel left out and engage in other non-academic activities such as checking messages on mobile phones. In the current study, the instructor consciously made it a point to come down from the dais at regular intervals, and deliver the lecture from the position where the first or the second rows of students were seated. This ensured that even back benchers got an eye contact from the instructor at least once in a while. 73% students found this to be a very effective strategy. However, in another study, Armstrong & Chang (2007) did not find an evidence to link seat location with student performance.

Careful use of jokes or humorous comments also eases the atmosphere. A teacher with 'sense of humor' is always more popular in the student community. According to Korobkin (1988), classroom humor is a twentieth-century phenomenon and acts to increase retention of material, student-teacher rapport, motivation, positive attitude and creativity; simultaneously academic stress, anxiety toward the subject matter and class monotony are decreased. Humour also acts to bring synchronicity among the audience, and they tend to become more receptive to the lecture. However, care must be taken not to use these in excess or in a mode of ridicule, as seriousness towards learning and respect for the teacher might also drop with the same. A balance has to be achieved as the real goal is learning, and entertainment is simply a tool to facilitate the same.

The author has found from personal experience that the sequencing of the different pedagogical tools is important to have the desired effect. e.g. Starting with music might sometimes divert the students' attention if not delivered in the context of the lecture. Also, at times, the teacher may need to stand on the dais rather than moving, e.g. while telling a story, so that students too feel and model the focus the teacher is experiencing.

CONCLUSION

According to Seymour & Heweitt (1997), classroom climate and faculty pedagogy are the major factors that contribute to student choices with respect to pursuing science majors. In the current study, different pedagogical tools were used for engaging large classes of General Biology with varying effectiveness towards improving classroom climate. Since today's student has access to various online sources of information including e-books and recorded lectures, the teacher's job in the classroom becomes more than just plain information delivery. Again, it need not be overemphasized that for a teacher at any level, student satisfaction is an important criterion that requires pedagogical improvements and friendly relations between students and professors (Mizintseva *et al.*, 2016). Add to that the class strength of 200-500, and the challenge becomes immense. This study was an effort to break the monotony in the classroom by employing diversity in the teaching approach, where music, anecdotes, question and discussion, to name a few, were used to supplement the concept delivery to students. This strategy has the advantage of taking care of an average listener's attention span where every few minutes of a 50-minute lecture is interrupted with story, question and discussion (Allen and Tanner, 2005). Inclusion of short video clips (often provided by the publisher of the textbook followed in the particular subject) has also been found to be useful in driving home 'the point'. The author recognizes that some content may need to be cut down to allow time for inserting such activities in the classroom. The removed content may be delivered via the 'flipped classroom' approach or covered in tutorial classes (Bergmann & Sams, 2012).

Although this work was carried out with the students belonging to a particular university/ campus in mind, the author is sure of broader implications in similar educational scenarios worldwide. It is a humble realization that the present study combines the essence of teaching methodologies developed by expert teachers all over the world. Again, it is a practitioner-centred attempt at enhancing pedagogical dynamics in large classrooms, and a longer and tougher journey awaits the one willing to abandon tradition and embrace variety in pedagogical approach.

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REFERENCES

Allen, D. and Tanner, K. 2005. Infusing active learning into the large-enrollment biology class: seven strategies, from the simple to complex. *Cell Biology education*, **4**: 262-268.

Angelo, T.A. and Cross, K.P. 1993. *Classroom Assessment Techniques: A Handbook for College Teachers*. San Francisco: Jossey-Bass.

Armstrong, N. and Chang, S.M. 2007. Location, location, location: does seat location affect performance in large classes? *Journal of College Science Teaching*, **37**(2): 54-58.

Bergmann, J. and Sams, A. 2012. *Flip Your Classroom: Reach Every Student in Every Class Every Day.* Eugene, OR: International Society for Technology in Education.

Bloom, B.S. and Krathwohl, D.R. 1956. *Taxonomy of Educational Objectives: The Classification of Educational Goals*. Handbook 1: Cognitive Domain. New York: Longmans.

Bradshaw, M. and Hultquist, B.L. 2016. *Innovative teaching strategies in nursing and related health professions*. Jones & Bartlett Learning.

Catherine, M.K. 2010. Teaching large classes at college and university level: challenges and opportunities. *Teaching in Higher Education*, **15**(2): 175-185.

Chamany, K., Allen, D. and Tanner, K. 2008. Making biology learning relevant to students: integrating people, history, and context into college biology teaching. *CBE Life Science Education*, **7**(3): 267-278.

Crowther, G. 2012. Using science songs to enhance learning: an interdisciplinary approach. *CBE Life Science Education*, **11**: 26-30.

Daniel, K.L. 2016. Impacts of active learning on student outcomes in large-lecture biology courses. *The American Biology Teacher*, **78**(8): 651–655.

Enger, E.D., Ross, F.C. and Bailey, D.B. 2012. *Concepts in Biology* (14th edition). New Delhi: Tata McGraw-Hill Publishing Company Ltd.

Garg, K.C. and Gupta, B.M. 2003. Decline in science education in India – A case study at + 2 and undergraduate level. *Current Science*, **84**(9): 1198-1201.

Glynn, S.M. 1994. *Teaching science with analogies: a strategy for teachers and textbook authors* (Research Report No. 15). Athens, GA: University of Georgia; and College Park, MD: University of Maryland, National Reading Research Center.

Korobkin, D. 1988. Humor in the classroom: considerations and strategies. *College Teaching*, **36**(4): 154-158.

Lemke, J.L. 1990. *Talking science: language, learning, and values*. Ablex Publishing Corporation, 355 Chestnut Street, Norwood, NJ 07648.

Mizintseva, M.F., Komarova, T.V., Sardarian, A.R. and Yakubova, T.N. 2016. Key aspects of managing the students' satisfaction with the learning environment at the international university. *Indian Journal of Science and Technology*, **9**(36): 1-14.

Parker, M. 2016. Teaching cell biology through stories: marvels of the (squabbling) cell. *The American Biology Teacher*, **78**(9): 774-775.

Seymour, E. and Hewitt, S. 1997. *Talking about leaving: why undergraduates leave the sciences*. Boulder, CO: Westview Press.

Wood, W.B. 2009. Innovations in teaching undergraduate biology and why we need them. *Annual Review of Cell and Developmental Biology*, **25**: 5.1-5.20.