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EDUCATIONAL FORUM

Actualizing mastery learning in preclinical medical education through a formative medical classroom

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ABSTRACT

Assessment has one of the most significant influences on student learning. Since assessments tend to direct students' learning efforts toward the intended learning outcomes, it is prudent to consider assessment as learning tools for improving the transfer and retention of learning and can rightly be considered as the bridge between teaching and learning. Aligned to Bloom's theory of "mastery learning," classroom-based formative assessments, combined with the systematic correction of learning issues can provide the learner with a more appropriate quality of instruction than what is possible under more traditional instructional approaches. This article reviews the evolving concept of classroom-based formative assessments in medical education and highlights its formative potential in preclinical years of medical curriculum. The suggested schema of "formative medical classroom" explores the possibility of seamless incorporation of formative assessment classroom techniques (FACTs) within classroom instruction in preclinical medical subjects and emphasizes that integration of FACTs within instructional activities can aid in timely diagnosis of learning issues and aid in planning suitable instructional adjustments.

KEY WORDS: Assessment; Classroom; Formative; Medical Education

> "*If we are finally to connect assessment to learner improvement in meaningful ways, we must come to see assessment through new eyes."* (Stiggins, 2002)[1]

INTRODUCTION

Assessment is a central feature of any curriculum.[2] Any approach to the study of human learning has to account for the basic fact that students do not necessarily or even generally learn what they are taught, rather; it is assessment that drives learning.[3] Assessment is one of the most significant influences on a student's experience of higher education and improving assessment has a huge impact on the quality of learning.[4-6] The three components of education, namely, learning objectives, teaching methodology, and assessment have a high degree of interdependence and one cannot sustain without the other. Of all the different components of a medical education program, the assessment strategies profoundly direct and influences the way students learn. In fact, the curriculum is literally defined by the requirements of assessment. Students often work "backward" through the curriculum, focusing first and foremost on how they will be assessed and what they will be required to demonstrate.[7] Since assessments tend to direct students' learning efforts toward the intended learning outcomes, it is prudent to consider assessments as learning tools for improving the

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transfer and retention of learning.[8] It can rightly be considered as the bridge between teaching and learning. An assessment system that enables teachers to assist students in developing and achieving their learning goals is a vital component of a learner-centered curriculum.[9] Hence, to recognize the compelling effects of assessment on learning behavior of students and to capitalize on the capacity of assessment for desired learning is a powerful means of reconceptualizing and repositioning the practice of assessment.

LEARNING THEORIES AND CLASSROOM-BASED ASSESSMENTS

The relationship between instruction and what is learnt as a result is complex. Even when instruction is well-designed and students are motivated, improvements in student capabilities are, in general, impossible to predict with certainty. Gaps often exist between what is taught and what students actually learn. Frequently, these gaps do not show up until after students are assessed in summative examinations. At that point, it is often too late to go back and modify the lessons, particularly when assessments given months and even years later point out the gaps in learning.To overcome this inefficient cycle of backfilling the gaps, educators need better ways of determining where their students are in their thinking and understanding before and throughout the instructional process. As a result, they are better able to monitor that gap as it closes.[10] Aligned to Bloom's theory of "mastery learning," the process of formative classroom assessment, combined with the systematic correction of learning difficulties can provide the learner with a more appropriate quality of instruction than what is possible under more traditional instructional approaches.[11] In other words, "*more variations in instructional strategies are likely to reduce the variation in students' achievement."* The essentials of mastery learning include two essential elements (1) instructional alignment and (2) feedback and correctives.[12] Significant enhancement in learning mandates feedback to be paired with correctives, i.e., activities that offer guidance and direction to students on learning issues. Due to students' individual differences, no single method of instruction works best for all. To help every student learn well, therefore, teachers must differentiate their instruction, both in their initial teaching and especially through corrective activities.[11] To be optimally effective, correctives must be qualitatively different from the initial teaching. They must provide students with an alternative approach. The best correctives present concepts differently and involve students in learning through different strategies. They incorporate different learning styles, learning modalities, or types of intelligence. To be truly effective, Bloom stressed they must be combined with the second essential element of mastery learning, i.e., instructional alignment. Reducing variation in student learning and closing achievement gaps requires clarity and consistency among all instructional components.

A science teacher must be able to engineer effective learning environments and understand the cognitive theories of learning to accomplish mastery learning. Zone of proximal development, one such cognitive theory of learning, is the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem-solving under guidance or in collaboration with more capable peers. As per Vygotsky's zone of proximal development perspective, learning is viewed as a profoundly social process [Figure 1]. Dialogue with the teacher and peers plays crucial role in learning.[13] The constructivist approach to teaching and learning posits that prior cognitive structures as an important part of cognitive development.[14,15] Students' existing ideas make a difference to their future learning. Hence, effective teaching needs to take these existing ideas into account [Figure 1]. During such interactions, the teacher reflects about learner's misconceptions and how to shape instruction to meet the learning needs by bridging their initial ideas with scientific analogy and understandings.[15]

Such interactions, taking into account the constructivist theory, can be achieved through classroom-based formative assessments embedded within the instructional activities that permit timely feedback, correctives, and instructional alignment. Since learning is unpredictable, assessment is necessary to make adaptive adjustments to instruction, and those assessment processes must impact the learner's willingness, desire, and capacity to learn. This ensures the active role of the learners in the process of learning. Medical education is largely based on connecting and relating previous knowledge base and deriving meaningful associations. Any unclarified or misunderstood link distorts the entire logical chain and concepts remain vague or ambiguous. Prior cognitive structures are an important part of cognitive development if the learner is to meaningfully acquire new information or concepts.[15] Hence, a constant monitoring of scientific understanding and comprehension should begin

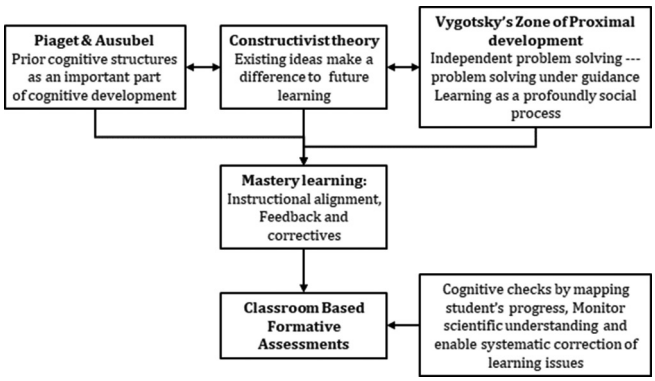

Figure 1: Classroom-based assessments aligned with learning theories

early in professional training. The scientific association should be assessed at every stage of learning, and constant adjustment in teaching strategies is crucial for desired learning outcomes, thus making the classroom mechanics a dynamic process. Classroom-based formative assessments as monitoring mechanisms, seamlessly embedded within the instructional activities, help to gain insight into learners' level of understanding and allow immediate and timely corrective measures [Figure 1]. Dealing with competency-based medical education, medical educationists' must ensure an optimal learning environment by utilizing a variety of formative assessment measures in the classroom, along with interim and summative assessments.[15]

Classroom assessments should essentially be a part of everyday practice by students, teachers, and peers that seek reflects on and responds to information from dialogue, demonstration, and observation in ways that enhance ongoing learning.[16] An assessment becomes truly "formative" when the evidence is actually used to adapt the teaching work to meet learning needs.[17] In addition to informing instruction and providing feedback, they initiate development of metacognitive and reflective skills. Another major shift that happens in a formative assessment-centered classroom is the recognition of the importance of learner's ideas. One key feature is that formative assessment should be regarded as a process rather than a particular kind of assessment. There are a number of formative assessment strategies that can be implemented during classroom instruction that range from informal observations and conversations to purposefully planned instructionally embedded techniques designed to elicit evidence of student learning to inform and adjust instruction.[2,18]

ALIGNING FORMATIVE ASSESSMENT CLASSROOM TECHNIQUES (FACTS) FOR A FORMATIVE MEDICAL CLASSROOM

Formative assessments within classrooms can provide information that facilitates better pedagogical practices and instructional outcomes, thereby encouraging the learner toward improved performance. In a formative assessment-centered classroom, teachers interact more frequently and effectively with students on a day-to-day basis, promoting their learning.[17] This interaction requires the teacher to step back from the traditional role of information provider and encourage a range of ideas among students. As opposed to inserting a few well-crafted formative assessments into the curriculum, instructors should understand that assessment practices need to be well grounded in the instructional process throughout the professional training. Learning theories and evidence advocate that formative assessment practices should be integrated into the minute-to-minute and day-by-day classroom activities. There is a substantial increase in student learning to the extent of around 70–80%, even when outcomes are measured with externally mandated standardized tests. In fact, there is nothing else that is remotely affordable and is likely to have such a large effect.[19]

FACTs are a variety of classroom assessment strategies, particularly suited for science classrooms wherein teacher promotes learner's thinking, uncover ideas, and use information about the learners' progress in learning to improve the instructional strategies.[20] These purposeful and planned teacher-to-student, student-to-teacher, and student-to-student verbal and written interactions involve a variety of assessment techniques so that different learning styles are catered. These techniques are used to engage students in thinking deeply about their ideas in science, uncover the preexisting ideas that can be used as starting points to build on during instruction, and help to determine how well the learners are progressing toward developing scientific understanding. This is analogous to a sick patient who goes to the doctor and is diagnosed with a clinical condition. To go beyond the diagnosis, the doctor would use the information collected diagnostically to design the best course of treatment so that the patient's health would improve. Precisely, that is the role of FACTs (formative assessment [FA]), diagnostic as well as therapeutic [Figure 2]. However, if the data are not used to inform teaching and learning, then it is merely a diagnosis without action.

The versatility of the formative classroom sparks students' interest, surface ideas, initiate an inquiry, and encourage classroom discourse all assessment strategies that promote learning rather than measure and report learning. A rich repertoire of FACTs enables learners to interact with assessment in multiple ways through writing, drawing, speaking, linking, designing, and interpreting. It helps teachers continuously examine how students' ideas form and change over time as well as how students respond to particular teaching approaches. This information is constantly used to adjust instruction and refocus learning to support each student's intellectual growth in science. Formal or informal, formative assessment is always purposeful.[21,22] The purposeful use of FACTs, on a continuous basis organizes the entire classroom around learning and inform teachers toward more effective learning experiences based on how their students think and learn.[20]

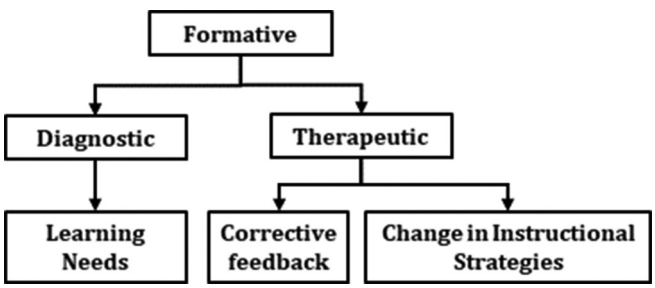

Figure 2: Role of FACTs in a medical classroom

FORMATIVE MEDICAL CLASSROOM

We propose a 13 step approach for seamless yet significant incorporation of classroom-based formative assessments in a preclinical medical classroom in four important phases; (1) planning, (2) implementation, (3) analysis, and (4) amendment phase. The stepwise intervention is depicted in the schema of formative medical classroom (Copyright no L-68933/2017) [Figure 3].

Planning Phase

1. Step 1: Define purpose of instructional activity.
   The purpose of instructional activity was defined in a clear and unambiguous manner in the form of a "purpose statement."
2. Step 2: State learning objectives for instruction.
   The measurable learning objectives for the said instructional activity which focused on fulfilling the purpose of instructional activity were planned and stated in a clear and concise manner.
3. Step 3: State learning domain for each learning objective.
   The learning domains, namely; cognitive, psychomotor, affective, and communication were specified against each objective.
4. Step 4: Identify learning strategy for each objective.
   The teaching-learning strategy for each objective was selected before instruction. This is a dynamic step which depends on the response of learners after appearing for classroom assessments. Based on the analysis of their responses, the strategy has to be revisited and can be revised for better understanding.
5. Step 5: Select the FACT which best suits the assessment of learning against identified objectives.
   The FACTs which best suites the defined objectives and content matter were selected to be administered at the end of the lecture class.

Implementation Phase

6. Step 6: Share learning objectives with learners and conduct lecture.
   On the day of instructional activity, the purpose statement, learning objectives were shared with the students before the lecture, after which, the instructional activity was carried out.
7. Step 7: Implement the chosen FACT at the end of the lecture class.
   The lecture class was concluded 10 min before for implementation of a chosen FACT. All the students were asked to submit their responses anonymously.
8. Step 8: Collect responses.
   The responses were collected from every student before they leave the classroom. It was reemphasized to keep the responses anonymous.

PLANNING PHASE
Step 1: Define Purpose of instructional activity
Step 2: State Learning objectives for Instruction
Step 3: State Learning domain for each learning objective
Step 4: Identify learning strategy for each objective
Step 5: Select the FACT which best suits the assessment of learning against identified objectives
IMPLEMENTATION PHASE
Step 6: Share Purpose statement, learning objectives and learning domains with learners during the lecture class
Step 7: Implement the chosen FACT at the end of the lecture class
Step 8: Collect responses
ANALYSIS PHASE
Step 9: Analyze responses
Step 10: Identify learning gaps
AMENDMENT PHASE
Step 11: Customize group feedback based on responses and plan learning objectives based on the gap analysis
Step 12: Subsequent instruction incorporating group feedback, correctives and revised learning objectives & teaching strategies
Step 13: Repeat Step 2 – 12 with variety of FACTs to support varied learning styles

Figure 3: Schema of formative medical classroom

Analysis Phase

9. Step 9: Analyze responses.

All the responses were analyzed for the extent of understanding and gray areas.

10. Step 10: Identify learning gaps.

The learning gaps were identified based on analysis of responses.

Amendment Phase

11. Step 11: Customize group feedback based on responses and plan learning objectives based on the gap analysis.
    A group feedback was planned that focuses on "what was answered correctly, what is the gap in knowledge and how to bridge the gap."

12. Step 12: Subsequent instruction incorporating group feedback, correctives, and revised learning objectives and teaching strategies.
    Based on the analysis of responses, subsequent instruction was planned and conducted incorporating feedback with correctives, revised learning objectives, and modified teaching strategies (if any).
13. Step 13: Repeat Step 2–12 with variety of FACTs to support varied learning styles.
    Likewise, the cycle can be repeated with different FACTs for different content areas.

The thematic areas within the subject to be assessed through FACTs can be selected on the basis of;

1. Importance within curriculum: "Must know" (core) part of curriculum conceptual.
2. Framework: Areas of conceptual understanding and reasoning.
3. Mathematical exactitude: Contents which warrant knowledge precision.

Similarly, the selection of FACTs can be based on its ease of administration and analysis, specifically suited to the chosen content area and catering to varied learning styles. The FACTs selected for inclusion should be reviewed against a set of following criteria as follows;[20]

1. Content validity: Whether, the FACT is useful in uncovering specific scientific concept or skill.
2. Engagement: Will the learners want to respond to the assessment technique?
3. Flexibility: Can the FACT be used in classroom configurations. Can it be adapted to fit a range of classroom environments and diversity of student population.
4. Inquiry based: Does the FACT promote the spirit of scientific enquiry and lead into an investigation of student ideas?
5. Ease of Use: Is the FACT easy to administer and respond to and does it use minimal class time? Are the materials readily available? Can the data be quickly collected and analyzed?
6. Reciprocal benefits: Is the FACT as beneficial to students in promoting learning as it is for teachers use in informing instruction?
7. Impact: Will the FACT make a difference in classroom learning environment and student achievement?

EXPERIENCE OF A RURAL MEDICAL SCHOOL

The inception of the idea was borne as a result of a need assessment carried out for medical teachers of Jawaharlal Nehru Medical College, Datta Meghe Institute of Medical College (Deemed University), Wardha, through an online survey aimed to explore their perception regarding mode and manner of FA at their workplace. Of the 93 responses collected, 82%, 78%, 73%, and 61% faculty stated that the value of FA for instructional realignments was not an attribute supported by most of the teachers, learners are not aware of the potential role and benefits of FA in their learning, format of FA does not support active student engagement, and FAs are not frequent within the curriculum, respectively. The qualitative data were suggestive of the sparse understanding of medical teachers regarding in-class formative assessment tools.[23]

The explored need led to a trial of classroom-based FA in the subject of Physiology at our Institute for seven content areas, namely; immunity, action potential, electrocardiogram, regulation of blood pressure, regulation of respiration, countercurrent mechanism of kidneys, and limbic system. The FACTs attempted for these content areas were classroom quiz, exit slip, 1-min paper, logic model for physiological regulations, one sentence summary, directed paraphrasing, and muddiest point, respectively, selection of which were based on the specified criteria as mentioned in preceding paragraphs. The responses of every FACT were collected and analyzed for learning issues that formed the basis of revised learning objectives of next instructional activity and clarification of less understood part. Pretest and posttest was the assessment modality to establish the efficacy of learning and feedback was obtained from experimental group regarding the utility of FACTs in learning. Discussion regarding specific methodology and results of this 1 year-long study is beyond the scope of this manuscript; however, it is worthwhile to state that the experimental group (who were subjected to FACTs) performed significantly well ($P = 0.001$, $P < 0.01$ was considered statistically significant) than control group.

FEASIBILITY AND SUSTAINABILITY OF FACTS

Training of medical teachers is of prime importance if classroom-based FAs are to be included within the curriculum of medical education. A teacher should be able to decide future course of action in response to what they learn about their students from such formative assessments and accordingly plan specific instructional modifications. The central challenge for educators and students in the faculty of medicine to adopt assessment for learning is partly due to the inadequate knowledge about the concept and its significant role in enhancing learning. To use formative assessment correctly, teachers need to optimize their knowledge in their domain area, pedagogical content, assessment knowledge, and knowledge of students' previous learning. The evidence gathered through formative assessment should be rather explored to determine whether the instruction needs to be modified and in what manner. The other challenge is reorganizing instructional time for effective inclusion of FACTs in the already existing time constraints within the curriculum. This can be tided over by proper planning in terms of specific areas within the subjects that are of prime importance and the

judicious selection of the type of FACT (in terms of its suitability to the content being taught, time required for administration, and time required for analysis). Actual FACT should not take more than 8–10 min of classroom instruction time and should be simple and engaging for the learners, as observed in the present study.[20] The cognitive demand for FACTs is yet another attribute which should be taken care of while planning for FACT. Ease of use is the most important indicator for acceptability of the technique. The ideal interim period between two successive instructional activities (on the same topic) where FACT is to administer should be of 2 days, thus providing adequate time for analysis of responses and instructional modifications. The probes within FACTs should be specifically based on the learning objectives of the instructional activity. The administration time can be further abridged using technology-based classroom assessments, though it has its own limitations.

This manuscript puts forth an instructional model that judiciously incorporates classroom-based assessments to monitor students conceptual learning and timely remediation within instruction to close the learning gaps.

CONCLUSION

Classroom-based formative assessments have evolved in its meaning and have spawned substantial interest and research in higher education. Among educators, researchers, and policy makers, there is amplified awareness that such formative assessments have the potential to provide missing linkages between classroom practice and large-scale assessments and perhaps most importantly, represent the next best hope for promoting better performance and competencies by learners. Resultantly, the locus of such formative assessment activities in medical education, for immediate and timely corrective measures, should be typically at the classroom level and the concept of formative assessment should resonate strongly with medical teachers.

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