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Original Article

Education Section

Formative Assessment Classroom Techniques (FACTs) for Better Learning in Pre-clinical Medical Education: A Controlled Trial

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ABSTRACT

Introduction: Formative Assessment Classroom Techniques (FACTs) can serve as a useful and timely diagnostic and therapeutic mechanism for tiding over learning issues created during classroom instructions.

Aim: Present study explored the efficacy of FACTs for better learning by diagnosing learning issues, timely instructional adjustments and feedback.

Materials and Methods: Experimental study with first year professionals in faculty of Medicine (n=200) were assigned to experimental group (n=100) and control group (n=100) by non probability convenience sampling. Seven methods of FACTs viz., Classroom quiz, Exit ticket, One minute paper, Logic model for regulation of physiological mechanisms, One sentence summary, Directed paraphrasing and Muddiest point were undertaken for seven Physiology lectures. Based on FACTs responses, subsequent seven instructional activities were revised to close the learning gaps. Conventional instructional method was adopted for controls. A p-value, Absolute Learning Gain (ALG) and Effect Size for pre test and post test of both groups were calculated. Learner's perception was recorded.

Results: Unpaired t-test revealed significant differences ($p<0.01$). ALG was 68.5-75% in experimental and 51.8-57.1% in controls. Effect size (Cohen's D) was 1.12.

Conclusion: FACTs can serve as a useful and feasible mechanism for diagnosing learning issues, tailor instructional modifications and facilitate timely feedback to improve learning.

Keywords: Academic achievement, Curriculum, Learning gap

INTRODUCTION

Assessment is a central feature of any curriculum [1] and can rightly be considered as the bridge between teaching and learning [2-4]. It is prudent to consider assessments as learning tool to improve the transfer and retention of learning as they tend to direct students' learning efforts towards the Intended Learning Outcomes (ILOs) [4]. In Medical Education, Classroom based teaching, a major strategy; is largely centred towards building upon existing cognitive frameworks of the learner. Any un-clarified or misunderstood link distorts the entire logical chain and important concepts can either remain vague or ambiguous [5,6]. The scientific theories for learning also largely capitalise upon learners baseline concepts [7,8]. Given the obvious potential of assessments in learning, they can serve a major role during classroom instructions as monitoring mechanisms to diagnose learning issues and strategize instructional techniques. Since the publication of Black and Wiliam's (1998) review of formative assessment; minimal scientific research on the impact of classroom based formative assessment on student achievement has been done, particularly in medical education [9]. Research evidence in literature that supports better educational outcomes with classroom based Formative Assessments is sparse; particularly in Medical Education [10]. This gap is even challenging, taking into consideration the organizational structures and time constraints of present medical curriculum, reconfiguration of daily classroom life and reorganization of the instructional time for effective formative assessments.

A need is evident to re-conceptualize and reposition assessments to effectively capitalise on its capacity to guide learning. Formative assessments within classrooms can facilitate better pedagogical practices and instructional outcomes [5]. It also ensures that assessment practices are well grounded in the instructional process throughout the professional training.

The present educational project explored the efficacy of formative assessment classroom practices in Physiology with validated FACTs for important content areas. The idea was to generate empirical evidence that support the impact of FACTs on academic achievement and establish relationship of assessment to learning that can inform policy and practice [11]. The possibilities of effective medical classroom reconfiguration that keeps learning on track and enables timely adjustments in teaching learning strategies was explored.

Present study thus aimed to explore the efficacy of FACTs for better learning by timely diagnosis of learning issues, instructional adjustments and feedback.

The project included implementation of seven FACTs during classroom instruction in the subject of physiology. Learning gain and perception of experimental group regarding the acceptability of FACTs were analysed.

MATERIALS AND METHODS

It was a Quasi Experimental, Open labelled, Mixed method study (QUAN→qual). Students of first professional year in faculty of Medicine (Batch 2016) enrolled in Jawaharlal Nehru Medical college, Sawangi (M), Wardha were included in the study by non probability convenience sampling (n=200). Study was conducted at Department of Physiology and School of Health Professionals Education and Research, DMIMS (DU).

Ethical considerations: The relevance and feasibility of the educational research work were evaluated by the Scrutiny committee for educational research. Ethical issues were assessed by Institutional Ethical committee (Ref no: DMIMS(DU)/IEC/2016-17/6040). Written informed consent of study population was obtained before the study.

Material/Test instrument: Six standardized and one validated method of FACTs were implemented as stated below;

A. Formative Assessment Classroom Techniques;

Standardized Methods: 1) Classroom quiz; 2) One sentence summary; 3) Exit ticket; 4) Directed Paraphrasing; 5) One-minute paper; 6) Muddiest point [12-15].

Validated Method: 7) Logic model for physiological regulation [16].

B. Evaluation was done by: Pre test, Post test and Feedback questionnaire

Seven thematic areas ('must know' of Physiology curriculum) were chosen for implementation of seven types of FACTs catering to varied learning styles and learning preferences. The selection of content areas was based on three features, namely:

1. **Importance within curriculum:** Only 'Must know' part of curriculum was taken;
2. **Conceptual framework:** Areas of conceptual understanding and reasoning were included and;
3. **Mathematical exactitude:** Contents which warrant knowledge precision were included.

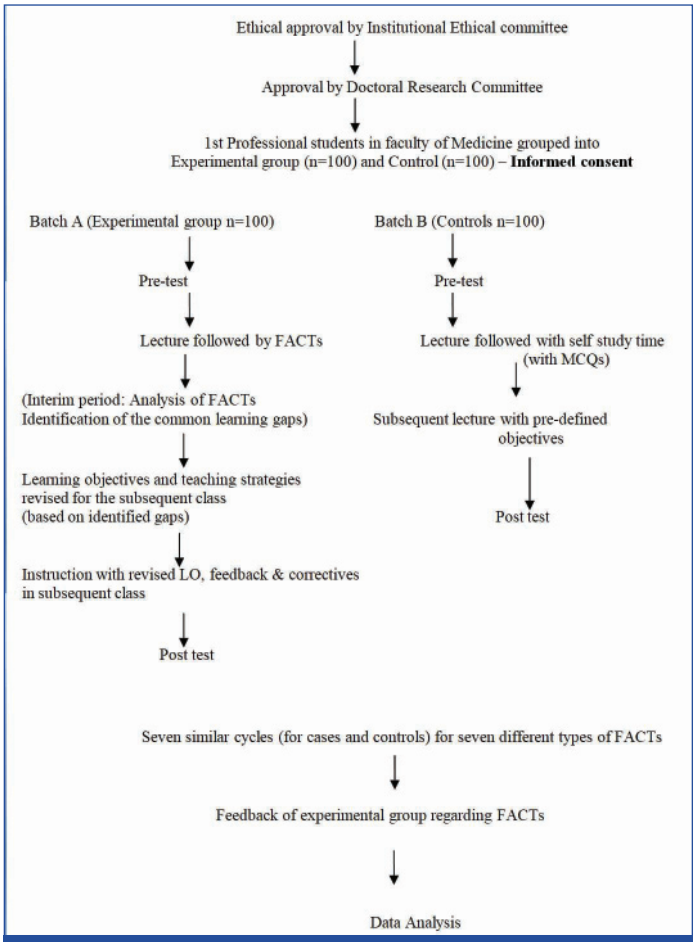
The content areas selected were Immunity, Action Potential, Electrocardiogram, Regulation of Blood Pressure, Regulation of respiration, Counter-current mechanism of kidneys and limbic system. The FACTs employed for these content areas were Classroom quiz, Exit slip, One minute paper, Logic model, One sentence summary, Directed paraphrasing and muddiest point respectively. These seven FACTs were selected on basis of: 1) Level of cognition that needs to be addressed; 2) Suitability to the nature of content; and 3) Catering to different learning styles viz., Visual, Aural, Verbal, Social, Solitary and Logical.

Workflow: The first year professional students student in faculty of Medicine (n=200) were randomly assigned to experimental (n=100) and control (n=100) group by Lottery method. Both the groups were subjected to pre-test. After the selected classroom Instructional activity, the selected FACT was conducted for the Experimental group. After FACTs, responses were collected anonymously, analysed and learning issues identified. Based on the identified learning issues, subsequent learning activity was planned for experimental group. It was taken care that the least comprehended part of the content was suitably dealt in the subsequent instructional activity by revising the teaching strategy and learning objectives. The control group was subjected to conventional method of classroom instruction with pre-defined learning objectives and strategies. The second Instructional activity was followed by post test for both the groups. Seven similar cycles were followed including seven thematic areas in physiology with seven selected FACTs, within a period of one year. Quantitative and Qualitative data were sought through a feedback questionnaire for capturing the perception and preferences of learners (Experimental group) towards the intervention. [Table/Fig-1] shows project work flow chart.

The instructional activity of experimental group was conducted in four phases namely; Planning, Implementation, Analysis and Amendment. The stepwise intervention is depicted in the Schema of Formative Medical classroom [Table/Fig-2] [17,18].

The detailed description of selected FACTs as against thematic area, its process of conduction, supported learning style and formative attributes are as depicted in [Table/Fig-3] [15,16].

Analysis of data: The analysis of data were done keeping in view the predefined objectives of the study. Statistical tool used for the analysis was SPSS version 16. [Table/Fig-4] depicts the analysis of data, based on the purpose as per objectives of the study by using appropriate statistical tools.



[Table/Fig-1]: Project work flow chart.

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

[Table/Fig-2]: Schema of formative medical classroom (Copyright no.: L-68933/2017, Tripti K Srivastava, Vedprakash Mishra, Lalitbhushan Waghmare) [17].

RESULTS

The experimental group consisted of 49 (49%) male and 51 (51%) female students. The control group had 38 (38%) and 62 (62%) male and female students respectively. The pre test and post test scores of every FACT group (total 7) and every parallel control group (total 7) were compared by paired t-test and were found to be statistically significant for every group ($p<0.05$ was considered statistically significant). The pre test scores of every FACT group was compared with parallel control group to assess any baseline difference in knowledge between two groups. However, all seven (experimental with control groups) were statistically non-significant thereby establishing the fact that both groups were comparable with respect to baseline knowledge about the thematic area under consideration.

Sr. no	FACT	Theme	Value (Purpose for using specific FACTs)	Process (in brief)	FACT Hallmark
1	Classroom quiz Learning Style: Aural, Verbal, Visual	Haematology: Immunity	Classroom quizzes are effective FACTs for assessing cognitive learning in content-based courses. Its potent effect lies in what the scholars call "effortful retrieval". Frequent quizzing triggers a process that enhances long-term retention of just-learned knowledge. The very process of responding to a quiz triggers learning. The quiz can serve as a practice- test which guides students to focus on the vital course content, provides them with some assessment of their learning progress, and offers them a motivation to learn more.	Classroom instruction on Immunity ↓ At the end of Instruction, classroom quiz was conducted with 5 multiple choice questions as power-point presentation ↓ Answer to every question discussed at the end	Engage and motivate students Self Assessment Diagnose knowledge gap
2.	Exit slip/ticket Learning Style: Solitary	Muscle nerve Physiology: Action potential	The exit ticket is simply a question that is posed to all students prior to conclusion of a lecture. The question focusses on the most important concept taught within the lecture class.	Classroom instruction on Action Potential of a nerve fiber ↓ At the end of Instruction, students were asked to draw a flowchart depicting steps of generation of Action potential along with the ionic basis of various step ↓ Responses collected anonymously	Formal concept development and transfer, Self assessment Diagnose knowledge gap
3	One minute paper [14,15] Learning Style : Solitary	Cardiovascular System: Electrocardiogram	Minute Papers are particularly useful when assessing: "student recall and understanding. student evaluation of what they recall. student ability to self-assess their learning and understanding" It helps students absorb, digest, and internalize new material, moving it into long-term memory.	Classroom instruction on Electrocardiogram ↓ At the end of Instruction, learners asked to answer two questions; "What was the most important concept you learned in the lesson today?" "What concepts were less clear in the lecture today?". ↓ Responses collected anonymously	Activate thinking and promote metacognition, Self Assessment Reflection Diagnose knowledge gap
4	Logic model [16] Learning Style: Logical	Cardiovascular System: Regulation of Blood pressure	The proposed model helps the learners to understand regulation of physiological mechanisms with reference to varied physiological inputs resulting in varied outcomes. Embedding any physiological process into the framework of Logic model can aid in understanding the significance of logic model in explaining any program.	Sensitization about the principles of logic model ↓ Classroom instruction on Regulation of blood pressure ↓ Logic model for regulation of blood pressure : At the end of Instruction, students were asked to write about Input, Activities, Outputs and Outcomes regarding Blood pressure regulation. ↓ Responses collected anonymously	Formal concept development and transfer Idea exploration, Reflection, Peer assessment Diagnose knowledge gap
5	One sentence summary [15] Learning Style: Social	Respiratory physiology: Nervous Regulation of Respiration	This technique makes students distill, simplify, reorganize, synthesize, and chunk complex material into smaller, essential units that are easier to manipulate and remember.	Classroom instruction on Nervous regulation of respiration ↓ At the end of Instruction, students were asked to answer key questions on a piece of paper about the Dorsal respiratory group of neurons, Ventral respiratory group of neurons, Apneustic centre, Pnuemotaxic centre in terms of Who? Does what? To what or whom? When? Where? How? Why?, for regulation of respiration. ↓ Responses collected anonymously	Formal concept development, Metacognition Self Assessment Reflection
6	Directed Paraphrasing [15] Learning Style: Social	Renal Physiology: Countercurrent mechanism of Kidneys	Students summarize the content of a reading assignment, a lecture, a discussion, or a lab to a defined audience for a specific purpose, in their own words. Because students must paraphrase material, they must work to understand it in depth and internalize.	Classroom instruction on counter-current mechanism of kidneys ↓ Directed Paraphrasing: 10 min before the end of instruction students were asked to write in brief about the counter current mechanism of kidneys for peers as defined audience ↓ Responses collected anonymously	Provide stimuli for scientific discussion, Formal concept development and transfer, Metacognition Self Assessment Reflection
7	Muddiest point (Electronic Mail) [15] Learning Style : Solitary	Central nervous system : Limbic system	The learners are asked to reflect upon the contents taught and note the poorly understood part of the lecture. It enables the teacher to weigh the contents through the students' perspective.	Classroom instruction on Limbic system ↓ Muddiest point: Students were asked to mention about the most confusing/poorly understood part of the lecture via an Online Survey (survey monkey) platform. ↓ Online responses received	Activate thinking and metacognition Self assessment Diagnose knowledge gap

[Table/Fig-3]: Framework for classroom based formative assessment in physiology [14-16].

Post test scores between experimental and parallel control group (for every FACT) were compared for significance by unpaired t-test and were found to be statistically significant as depicted in [Table/Fig-5].

Comparison of sum of post test scores for all 7 FACTs in experimental groups and control groups: From [Table/Fig-6] it is observed that in experimental group after exposure to all the seven type of FACTs, the mean score was 7.43±0.82, 95% CI (1.6,1.8) as compared to controls who had mean score of 5.65±0.96, 95% CI (1.6,1.8). These differences were statistically significant ($p<0.01$).

Effect size: The effect size estimates the effectiveness of an intervention by comparing it with a standard in quantitative terms. The effect size of the intervention (by FACTs) was calculated to be 1.12 by STATA version 14.1 software (StataCorp). The effect size of 1.12 suggests a percentile gain of 37 percentile. That is, students

Sr no.	Data	Purpose	Alignment with Objectives	Statistic/Validation of tool
1	Responses of every FACT	Identifying learning gaps	Appraise the formative potential of seven FACTs	-
2	Pre test and Post test (in each FACT group and parallel control group)	Compared for significance	Assess level of improvement in learning among Experimental (FACT) group and Control group	One tailed paired t-test Absolute learning gain Class average normalized gain
3	Pre test (every FACT group with parallel control group) Post test (every FACT group with parallel control group) Cumulative Post test of all FACTs with cumulative post test for all Controls	Compared for significance	Compare learning between Experimental (FACT) and control group	Unpaired t-test
4	Effect size of Intervention (FACTs)	To estimate size of difference (effect) without confounding with sample size		Cohen's D
5	Quantitative data of feedback	Preference for FACTs	To obtain feedback of cases regarding the acceptability of FACTs	Percentage distribution
6	Qualitative data of Feedback	Learner's view about utility of FACTs		Coding and categorization

[Table/Fig-4]: Data analysis chart.

FACT	Group	N	Mean	Std. Deviation	95% Confidence Interval of the Difference		p-value
					Lower	Upper	
Classroom Quiz	Experimental	92	7.41	1.26	1.55	2.18	0.037
	Control	95	5.54	0.90	1.55	2.18	
Exit Ticket	Experimental	93	7.26	0.83	1.32	1.87	0.041
	Control	94	5.66	1.04	1.32	1.87	
One Minute Paper	Experimental	94	7.36	0.75	1.71	2.26	0.033
	Control	93	5.40	0.94	1.72	2.26	
Logic Model	Experimental	91	7.21	0.62	1.27	1.72	0.033
	Control	93	5.71	0.90	1.27	1.72	
One Sentence summary	Experimental	93	7.77	0.65	1.71	2.20	0.045
	Control	92	5.78	1.13	1.71	2.20	
Directed Paraphrasing	Experimental	95	7.70	0.63	1.82	2.28	0.047
	Control	94	5.65	0.95	1.82	2.28	
Muddiest Point	Experimental	95	7.28	0.65	1.20	1.62	0.035
	Control	93	5.86	0.80	1.20	1.62	

[Table/Fig-5]: Comparison of Post test scores between experimental and parallel control group.

scoring at the 50th percentile on conventional instructional model would be predicted to score at the 87th percentile after incorporation of FACTs.

Learning gain for every FACT (Experimental) and Control group: The [Table/Fig-7] depicts learning gain for after every FACT group and control group, based on pre test and post test scores. The ALG was in the range of 68.5–75% in FACTs group and 51.8 – 57.1% in control group. The class average normalized gain was high, within the range of 0.71-0.76 for all FACTs and was medium for all control groups i.e., within the range from 0.52 – 0.58.

Group	Mean	Std. Deviation	95% Confidence Interval of the Difference		p-value
			Lower	Upper	
Experimental	7.43	0.82	1.67	1.86	0.001*
Control	5.65	0.96	1.67	1.86	

[Table/Fig-6]: Comparison of total scores in post test of experimental group (all FACTs) with control group by Unpaired t-test.

Topic	FACT	Experimental group			Control group		
		ALG (%)	CANG	Gain	ALG (%)	CANG	Gain
Haematology: Immunity	Classroom quiz	70	0.72	High	53.20	0.54	Medium
Muscle nerve Physiology: Action potential	Exit ticket	68.50	0.71	High	54.70	0.55	Medium
Respiratory physiology: Nervous Regulation of Respiration	One sentence summary	73.40	0.76	High	55.70	0.56	Medium
Cardio-vascular System: regulation of Blood pressure	Logic model	68.50	0.71	High	55.30	0.56	Medium
Cardiov-ascular System: Electroc-ardiogram	One minute paper	71.30	0.72	High	51.80	0.52	Medium
Renal Physiology: Counte-rcurrent mechanism of Kidneys	Directed parap-hrasing	75	0.76	High	54	0.54	Medium
Central nervous system: Limbic system	Muddiest point	71.10	0.72	High	57.10	0.58	Medium

[Table/Fig-7]: Learning gain for every FACT and control group.
ALG: Absolute Learning Gain.
CANG: Class Average Normalized Gain.

Analysis of feedback: In response to the question "Do you feel that in-class assessments should be practiced by teachers? Why?"100% students in experimental group agreed towards regular practice of FACTs in regular instructional activities.

The reasons quoted by students for regular practice of FACTs within instructional activity were grouped into eight categories viz., 1) Revision; 2) Better learning; 3) Better memorization; 4) Conceptual understanding; 5) Dealing with learning issues; 6) Improved confidence; 7) Self assessment; 8) Makes learning interesting. The verbatim responses are depicted in [Table/Fig-8]. The categorized themes are in congruence with the inherent merits of Classroom based Assessments for better learning.

Triangulation of data for interpretation: For a better interpretation of ALG, it was triangulated with the qualitative responses of the learners by sequential explanatory strategy. It was inferred that the learning gain was maximum with 'Directed Paraphrasing', followed by 'one sentence summary'. Both the techniques include summarizing the contents taught during instruction that enables quick revision. The qualitative comments reflect the same wherein maximum responses favoured the 'quick revision' quality of FACT. Next in line was classroom quiz that require effortful retrieval of contents. The same was observed in qualitative comments wherein learners quoted 'better memorization' as next best attribute of FACT.

	Coding	% of responses	Few Verbatim Responses
Why do you feel that in-class assessments should be practiced by teachers?	1.Revision	26.5	"We can revise what was taught" "Is very good for revision" "Automatic revision is done" "Entire thing can be revised" "A good method for revision in a short time" "quick revision" "could revise the entire lecture in an interesting way" "framing my own answers allowed to think and revise. "it is good to learn by revising again the entire lecture"
	2. Better Learning	21.2	"they helped in learning" "learning and memorizing" "I could learn most of the things in the class itself" "we can learn better as feedback was given" "Feedback made things simpler for learning" "it was better to learn by realizing the weaker areas and working upon them" "especially quiz and paraphrasing helped in learning"
	3. Better Memorization	13.8	"could remember because it was revised at the end of the class by small tests" "interesting tasks helped to remember the things" "I could remember better" "helpful in remembering" "could remember because it was revised" "learning and memorization was easy by replying to the questions asked" "teachers ask questions in interesting ways which helps in better learning and memorization"
	4. Conceptual understanding	13.8	"answering by forming flow chart was good to learn and connect" "logic model was interesting to understand relationships between different physiological determinants" "it was interesting to write in own words to explain the concept" "concepts could be learned better this way" "helped me in understanding physiological relationships"
	5. Dealing with learning issues	9.57	"feedback helped in knowing the missing loops" "revision of less understood areas were done in the next class which was very helpful" "it is very good to re-explain the parts which were not understood…in fact it best part of the entire exercise and should be done after every class" "Based on our answers, the next class covered the less understood areas which was really helpful"
	6. Improved confidence	8.5	"I can now explain the topic of countercurrent, BP regulations, regulation of respiration etc." "it helped to develop a sense of confidence about the topic" "since the entire topic is revised in a way. We are in a better position to answer the queries related to it" "explaining the topic to my classmate improved my confidence about the subject" "since I had to explain to others, I first tried to understand the things properly and that helped"
	7. Self assessment	4.2	"I could assess my own learning" "I could guess how much I have learned and what remains" "a good way to quickly assess oneself" "I could realize the learning objective which I couldn't understand well"
	8. Makes learning interesting	3.1	"the variety of exercises were good and helped in better learning" "re-explaining the less understood areas was a good gesture that generated interest in the topic" "Physiology is all about concepts and the various classroom tests make it really interesting"

[Table/Fig-8]: Coding of open-ended responses.

DISCUSSION

The analysis of responses to formative assessment gives a rich repertoire of information that can be explored for subsequent instructional activities to close the learning gaps. One useful concept is an assessment triangle that shows the presence of three elements in any type of assessment: a model of student cognition, which describes how students develop competencies in an academic domain and how they organize their knowledge at different levels of development; observations, which are the tasks or activities in which students' performance can be observed, scored, and evaluated for the purpose of gathering evidence of learning; and interpretation, which is the rationale for making sense of and deriving inferences from the evidence gathered [19]. In formative assessment, a fourth element needs to be present i.e., effective translation of the interpretation of assessment performance to instructional decisions and actions. The quality of inferences derived from the assessment will depend on how well these four elements have been linked [15].

In the present study, the responses of every FACT was analysed and remedial actions were planned as depicted in [Table/Fig-9]. It is important to state that learning gaps existed after every instructional activity.

[Table/Fig-9] shows analysis of FACT responses for identifying learning issues and teaching modifications thereof.

The implementation of FACTs in the present project specifically addressed four essential elements of classroom formative assessment process: 1) identifying the learning gap; 2) feedback; 3) student involvement; and 4) learning progressions. Identifying the gap, Royce Sadler's seminal work involves understanding the difference between what students know and what they need to know, and how instruction will be most effective to meet desired learning goals [19]. All FACTs in the said project incorporated group feedback in subsequent classroom instruction which was based on student responses. It actively involved the learners and their learning status was shared by the researcher.

Learning progressions break down a larger learning goal into smaller sub-goals. It is necessary for helping teachers locate students' current learning status in relation to a continuous set of skills needed to master the learning standard. Popham defines learning progressions as a "carefully sequenced set of building blocks that students must master en route to a more distant curricular aim" [20]. Learning progressions carefully lay out the progression of concepts and skills learners acquire overtime and that leads to

Sr no.	Topic	FACT	Learning objectives	Learning objectives for subsequent class	Analysis of FACT responses	Measures adopted to overcome the gap	Revised learning objectives for subsequent class
1	Immunity	Class-room quiz	Define immunity. Classify and describe the types of immune mechanisms. Compare the types of acquired immunity on the basis of their mechanism of action. Discuss in detail the physiology of immune response.	State the type of antibodies. Draw and label the structure of an antibody. State the function of each type along with their characteristic features. Explain the applied aspects of immunity.	Poorly understood role of Antigen Presenting cell (APC) and Major Histocompatibility Complex (MHC) in cell mediated immunity.	1.LO revised for subsequent class 2.Video demonstration of APC and MHC concept for better understanding	Explain role of Antigen Presenting cell (APC) and Major Histocompatibility Complex (MHC) in cell mediated immunity. State the types of antibodies. State the function of each type along with their characteristic features. Enlist the applied aspects of immunity.
2	Action potential	Exit ticket	Define Action Potential (AP) and Graded AP Differentiate between AP and graded AP Describe the different phases of AP Discuss the ionic basis of AP	Discuss the various properties of AP Describe the method of recording of AP	The step of 'after depolarisation' and its ionic basis were not included in 65% of the responses.	LO revised for subsequent class with Recap of phases of AP and its ionic basis.	Revise the phases of AP in a nerve fibre and its ionic basis. Discuss the various properties of AP Describe the method of recording of AP
3	Electroc-ardiogram	One minute paper	Describe the conducting system of heart Explain Normal ECG: Recording conventions Explain ECG waveforms and intervals Describe unipolar and Bipolar leads of Electrocardiography (Recording of ECG)	Explain Cardiac vector or cardiac axis Explain the clinical significance of ECG. Current of injury Myocardial infarction Heart blocks	Best comprehended aspect: ECG waveforms Least comprehended aspect: PR and QT intervals.	1.LO revised for subsequent class	Elaborate on the clinical significance of 'Segments' and 'Intervals' in an ECG Explain Cardiac vector or cardiac axis Explain the clinical significance of ECG with regards to : Myocardial infarction Heart blocks
4	Regulation of Blood pressure	Logic model	Define Blood Pressure Understand the concept of logic model Describe the Regulation of blood pressure by logic model	Elaborate on the various blood pressure regulatory mechanisms. Enlist various determinants of BP	78% responses had unsatisfactory depiction and linking of 'Process' and 'output' chain of blood pressure regulation logic model. 42% responses had incomplete listing of 'inputs' in blood pressure regulation logic model	1.LO revised for subsequent class 2. Hand-outs of logical framework of blood pressure regulation was distributed.	Revise the logic model of blood pressure regulation Enlist various determinants of BP
5	Neural Regulation of Respiration	One sentence summary	Classify the various mechanisms of regulation of respiration Enumerate various neural centres for regulation of respiration. Draw the diagram of neural centres	Discuss the nervous regulation of respiration Discuss pathological patterns of respiration.	Role of Pneumotaxic centre and Apneustic centre in automatic regulation of respiration was erroneously stated by 71.9%	1.LO revised for subsequent class 2. Concept explained by role play wherein students were allotted the name of various respiratory centres and were coached to explain their part in regulation of respiration.	Describe the effect and interplay between various respiratory centres in automatic regulation of respiration. Enumerate pathological patterns of respiration
6	Counter-current mechanism of Kidneys	Directed parap-hrasing	State the factors resulting in concentrated urine formation Define Counter-current mechanism Discuss in detail the mechanism of counter current exchange system Discuss the role of Urea in urine concentration	Discuss in detail the mechanism of counter-current Multiplier system State few disorders of urine concentrating abilities	64% responses did not include the role of urea in concentrating urine. 31% responses were incorrect regarding filtration, absorption and secretion in various segments of a nephron.	1.LO revised for subsequent class 2.TL strategy revised	Revise the function of various parts of nephron in concentrating urine(Answer in YES/NO). Elaborate the role of urea in urine concentration: Interactive discussion Discuss the mechanism of counter-current Multiplier system Hand-outs of various disorders of urine concentrating ability
7	Limbic system	Muddiest point	Identify the location of the limbic system Enumerate the components of the limbic system Describe the Papez circuit and functional significance of the Papez circuit.	Enumerate and describe functions of the limbic system Explain pathophysiology of KluverBucy Syndrome	68% of the responses stated 'functional significance of Papez circuit' as the most muddiest point. 16% of the responses stated the 'location of limbic system within CNS' as the most muddiest point.	1. LO revised for subsequent class 2. 3D Video demonstration of location of limbic system within CNS	Revise the location of Limbic system within CNS Explain the significance of Papez circuit Enumerate and describe functions of the limbic system Explain in brief KluverBucy Syndrome

[Table/Fig-9]: Analysis of FACT responses for identifying learning issues and teaching modifications thereof.

deeper connections among a larger network of concepts and skills. In pre clinical phase of Medical education, the learners need to be assessed on a broader range of level of knowledge and skills. Through continual evidence gathering and fine tuning of student instruction, as acquired through FACTs, teachers can begin to narrow their differentiated focus and move towards the specific learning goals. It is important to understand that properly articulated learning progressions, and their subsequent assessments, will allow teachers to understand where their students are and allow them to refine that process with more granularities to move students toward

their goals throughout the year. This very concept of explicitly defining learning objectives and focussed assessments as against LO were explored within the said project.

Learning through classroom Formative Assessments: Present study demonstrates better learning gain after implementation of classroom formative assessments as compared to control group. Better learning was a consistent feature with every FACT as compared to controls. Supporting evidences documented by Paul Black and Dylan Wiliam states that, students who are taught by teachers practising classroom formative assessments, achieve in six/seven months what otherwise would take a year [9]. More importantly, these improvements were consistent across countries (including Canada, England, Israel, Portugal, and the United States), as well as across age brackets and content areas. Similar gains were recorded when student achievement was measured with externally mandated standardized tests [5]. Most claims about the benefits of formative assessment begin with the Black and William's review of research on formative assessment. These studies had some common features like the use of some of the features of formative assessment (e.g., feedback, teacher questioning, student self-assessment). These features were associated with moderate-to-large effect sizes. In analysing studies conducted on wide range of students, the average effect sizes from those receiving formative assessment treatments were between 0.4 and 0.7. Common effect size guidelines put an effect size of 0.2 in the "small" category. A "medium" effect size is 0.5. A "large" effect size is 0.8.

Meta-analysis of studies on the impact of classroom formative assessment on K–12 student achievement concludes that - if only the studies hewing to rigorous methods are examined; the effect sizes of formative assessment are usually positive [21]. The impact of formative assessment in improving the performance of students in exams was also documented by Greer L [22]. This study compared the performance of students from different cohorts; one that used non-formative assessment, and another that used a new formative assessment strategy. The findings indicated that changing the mode of assessment effects student performance, which on the whole was better for the cohort that used the formative assessment. Study by Paschal CB denotes that learning of systems physiology concepts is effective when in-class quizzes and activities with instant feedback via., a wireless classroom communication system are used in place of traditional learning activities [23]. In a related study, authors concluded that when effective communication principles are adhered to in classroom formative assessments; an effect size of 0.79 is obtainable [24]. The effect size in the present study was estimated to be 1.12, large enough to indicate the efficacy of FACTs in better learning.

Literature suggest the possibility of Classroom FAs exerting more influence on teaching practices (e.g., creating a positive learning environment) than on learning. It helps students learn how to be better learners [24,25]. There is no best FACT or collection of FACTs that can improve teaching; rather, it is a choice essentially on the basis of established curricular goals and is targeted towards improving instruction. Before selecting a FACT, key ideas to be borne in mind are: 1) The type of pedagogy embedded within the FACT as the best match for the contents; and 2) The FACT that can produce best information to inform my teaching. It is important to be aware that irrespective of the method of FACT employed with educational interventions, due consideration must be given to the different learning styles of the students from the different disciplines as considered in the present study.

Feasibility Aspects: Training of medical teachers is of prime importance if classroom based formative assessments are to be included within the curriculum. The other challenge is reorganising 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 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 minutes of classroom instruction time and should be simple and engaging for the learners, as observed in the present study. The cognitive demand for FACTs is yet another attribute which should be taken care of while planning for FACT. Literature suggests a mix of the levels of cognition. Ease of use is the most important indicator for acceptability of the technique, as also evidenced by the present study wherein Classroom Quiz, One Minute Paper and One Sentence Summary were the most preferred methods that are the simplest to administer and respond. The general implementation attributes of the FACTs used for the present study is shown in [Table/Fig-10].

Sr no.	FACT (Level of cognition)	Ease of Use	Cognitive demand	Time demand	Time for analysis
1	Classroom quiz (Recall)	High	Medium/High	Medium	Low
2	Exit Slip (Understand)	High	Low/Medium	Low	low
3	One minute paper (Evaluate)	High	Low/medium	Low	low
4	Logic model (Analyse)	Low	High	Medium	Medium
5	One sentence summary (Apply)	High	Medium	Medium	Low
6	Directed Paraphrasing (Create)	Medium	Medium/High	Medium	Medium
7	Muddiest point (Evaluate)	High	Low/Medium	Low	low

[Table/Fig-10]: General implementation attributes of the FACTs.

The ideal interim period between two successive class (on the same topic) where FACT is administered should be of two days, thus providing adequate time for analysis of responses and instructional modifications. The probes within FACTs should be specifically based upon the learning objectives of the instructional activity. The administration time can be further abridged by using technology based classroom assessments, though it has its own limitations. The limitation realised was that the responses were not prompt and therefore the analysis took longer time than anticipated.

CONCLUSION

The present study has put forth an instructional model that judiciously incorporates classroom based assessments to monitor student's conceptual learning and timely remediation within instruction to close the learning gaps. The study concludes that FACTs can be seamlessly integrated within instructional activities in medical classrooms and incorporation of such activities improves learning. Learners' favour FACTs that enable quick revision and FACT strategies catering to different learning styles make it more suitable and sustainable within classroom dynamics. Resultantly; this may strengthen the scientific concepts taught in the classroom through a well monitored navigation towards higher levels of learning.

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