

Assessment of 21st Century Skills in STEM programs

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Abstract: Assessments are done in order to rank and grade learners and also to know what has been learned. 21st century skills have been defined and are dynamic. Further these have been classified in 4 categories: Cognitive, Literacy, Life skills and Social Skills. Assessing these skills is a challenge at any level of education. This is a study on the assessment of 21st century skills for grades 3 and 4. The assessment tool was designed and is presented along with which skill each question addresses, Results of the study show the assessment instrument was impactful and such instruments might be used to assess 21st century skills.

Keywords: Assessment, 21st Century skills, Cognitive, Literacy, Life skills, Creativity, collaboration, Communication. Critical thinking

1. Introduction

We are in the 21st century and we are going through rapid transformations. 21st century skills have been documented by OECD and PISA. It is pertinent to note that apart from using assessments to rank or grade students, it is a vital tool to examine the learning process and progress. To know what the taught have actually learnt, effective instruments of assessing are a must

21st Century skills have been divided into 3 categories: learning or cognitive, Literacy and Life skills• .

The Learning skills are: Creativity, Critical thinking, Communication and Problem solving.

Literacy skills are: Information, media and technology literacy

Life skills are: Flexibility, leadership, initiative, productivity, and social skills.

The Social skills are: Collaboration, forming teams, people management and negotiation

These skills have been studied and in fact formed the basis of STEM as 4 values: Creativity, Critical Thinking, Communication and Collaboration. The OECD reinforces this and has presented a detailed description and a framework for 21st Century skills• .

These skills are however not static , neither in their relative importance nor in their being displaced by other skills as can be seen by an excerpt from the World Economic Forum Jobs of the Future report•

With this background, the assessment of 21st century skills becomes difficult. As such the assessment of problem solving or creativity are difficult to assess as well as to impart. There have been attempts to guide this process. Significant amongst these are a workshop summary on assessing 21st century skills. •

Also notable are the efforts by some to assess and use the data from such assessment. A table from this paper describes for example, in Singapore, Critical thinking, civic literacy, collaboration, communication are used and there is a system of progression as in Subject-specific syllabi provided online describe expected progressions for learners based on how students at various stages think, develop, and learn• . PISA too is engaged in modifying its assessment to test a more diverse range of skills. •

In this context, we have been running a program for 3 years on STEM education as an in school program for 3rd and 4th graders. A unique method of assessment has been used and the assessment style, questions and data from the assessment is presented.

A paper for engineering education first year has also been designed mainly to test creativity, communication and STEM literacy... This can be made available on request and is not a part of this paper as there is only a very limited trial which was carried out with these question papers

2. Research Question

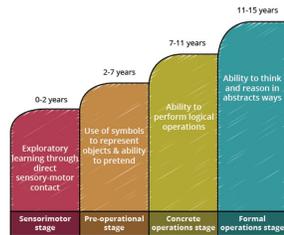
How can 21st Century skills be assessed on the canvass of STEM subjects taught in the classroom

Seeking an experimental answer to this question has been the quest.

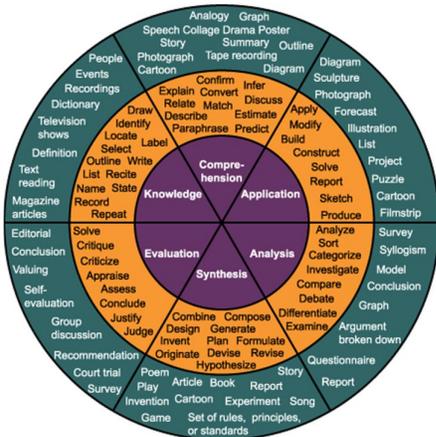
3. Methodology

An assessment instrument was designed and administered to around 120 students of grade 3 and 120 students of grade 4. One of the assessment papers is given here. After the assessment impact was measured by analysing the results and also examining individual responses. Of students which tells a story not evident from the data.

During our framing of assessment we have been guided at the theoretical level by Piaget stages and Blooms Taxonomy (three Taxonomies of Bloom: Cognitive, Psycho motor, and Attitudinal)



Piaget's stages Figure 1



Bloom's cognitive taxonomy Figure 2

Both of these are in wide use in alignment of assessment. We have used Piaget's stages to scope the age appropriateness and Blooms to structure the assessment

We also developed a framework for the teaching of STEM as a discipline. In this 6 different areas were considered as the building blocks: 21st century skills namely collaboration, Creativity, Communication, and Critical thinking. STEM literacy, Engagement, making

connections with environment computational thinking and ethics.. It is in this background that assessments were designed and the results are presented below. The assessment has questions which are unique and designed to trigger discussion either within a group or with oneself.

The program is a lab course in which the class is divided into 8 groups. Each group carries out activities and tasks during the term which are aimed at strengthening the 21st century skills, but using the backdrop or material to which the student has already been exposed. So ordinarily, in our course no new terminology is to be learned

Final assessment at the end of a term is described below for grade 4

The first part was group questions to be done by the entire group and the second part is to be done individually

“Q1. A box with different plant parts is given to you. There is a picture of a plant attached to the box. Choose parts of plants which are similar to the ones in given picture. Each student from the group has to pick one part of plant from the box. Other students can guide him/her while choosing. Once the chosen part is placed on the table it cannot be placed back in the box. Once all the parts are chosen your group has to make a complete plant by arranging the parts. Also write about the plants you have made and what is special about it?

15 Marks

- Q2. Read the text given below and make at least 3 questions based on it.

Rahul was playing cricket with his friends. While playing the ball was hit in an abandoned (left) place. Everyone was scared to get the ball. Finally they all decided to go and get the ball together. They all went inside that place. It was full of tall grasses, creepers and different types of trees. The grasses have sharp edges, so they all walked carefully. The trees have all sorts of leaves. Some had big leaves, some had small and in some trees the main leaves were divided into many small leaves. Some trees even had fruits on them. They searched for their ball but they didn't get it anywhere. Suddenly Rahul's

leg knocked on something hard. He looked down and found that his leg was knocked to a very old thing which looked like a book. Rahul lifted it and his guess was right. It was an old book. He showed other the book he got. But before anyone could say anything, the book started talking. The book said that it was a magical book and it had been lying in that place for 600 years. The book told that he was the magical book of Tenali Rama who was the great scholar of King Krishnadeva Raya. The book told that before dying Tenali buried it deep in the ground. He thanked the children for taking it out. Rahul asked the book how it was magical. The book told it helped Tenali Rama to solve all the problems that he came across. The book told the kids that even after being buried; it was still able to know what was happening around the world during all these years. The book said that Akbar was a great king of north India who ruled for half a century. Then he told about Shivaji and the wars between Mughals and Marathas. The book also told about the coming of British government in India and how Indian people got their freedom. The children were surprised to know so much from the book. Rahul urged the book to come home with him. But the book said that it was not easy for anyone to take it home easily. He gave the children a puzzle to solve and told them whosoever solves the problem can get access to use it but it will not go to anybody's home.

a. The book gave Rahul and friends the following puzzle but he turned some of the numbers into symbols with his magic. Help Rahul to solve the problem: **4 Marks**

$$\begin{array}{r}
 \alpha 1 \sqrt{44\beta} \alpha \beta \\
 \underline{4\alpha} \\
 \alpha \beta \\
 \alpha \beta \\
 \hline
 \times
 \end{array}$$

What is the value of α and β in the above question?

b. You are curious about many things around you. The magic book has all the answers. Which three questions will you ask the magic book and why? **7 Marks**

c. Make a timeline of India under different rulers as described by the magical book. (Like who ruled and from when to when) **4 Marks**

The 2nd part of the paper is the individual sections to be done by each student separately

Q1.a. a cricket match was played between students of grade 4. This was a unique match in which only 4s and 6s were counted as runs. In how many balls will the player score a century if he hits only 4s and 6s without missing any ball. Give three possible combinations of 4s and 6s to make century. **5 Marks**

b. If a player is hitting runs continuously, will he be able to score a century in 15 overs under the following conditions: **5 Marks**

- i. He can hit only six 4s and three 6s in all 15 overs.
- ii. Only single runs, 4s and 6s are counted. Doubles will not be counted.
- iii. There are 5 maiden overs. (In which no runs are scored)

Q2. Read the story given and point out any misguiding information giving reasons. **10 Marks**
 Samarth lives in Jaywalker, Rajasthan. The plants around his locality have tiny leaves, fleshy stems, Some are thorny, some have green stems and most plants have deep roots. During summer vacation, Samarth went to Shimla. There he saw pines and other conifers. He liked them a lot. While returning he brought some pine seeds with him. He planted them. After few days the seeds germinated. He watered them daily. After a month he noticed that the plant has developed a fleshy stem. After two months he noticed that the needle like leaves are reduced and turned into spines. He also noticed that within six months the stem has also turned green. Samarth was happy to see his pine plant adapted to desert conditions.

Q3. If you are a class monitor how you will do justice under the given situation:

Five students Neha, Riya, Kyushu, Raj and Rahul were sitting in a group and writing some story. Suddenly Neha started shouting. She was repeatedly asking about her pencil. She said that the pencil was with her all the time but someone stole it from her the moment she was drinking water. She then saw Kyushu holding the same pencil as hers. She blamed her for stealing her pencil. Khushi said that it was her pencil and she was writing with it all the time. Raj, who was sitting next to Khushi was watching the whole situation. The whole group came to you for justice.

10 Marks



Figure 3

The following are the conditions. Which one will you choose and why? (Give reasons to support your answer)

- Neha is lying about the pencil. She wants the pencil of Khushi.
- Khushi is lying and the pencil belongs to Neha.
- The pencil could be lying on the floor.
- The pencil is in the pencil box of Neha”

The above assessment was administered to 3 sections of Grade 4. All the topics in the paper relate to what has been taught in class during the term

5. Discussion

The research question was HOW can 21st century skills be assessed? Certainly a different method and basis of assessment is needed. In the conduction of the assessment it was noticed that in some groups of 5 there were mostly 2 or 3 who were working. Some refused to work with their group mates, sometimes for mundane reasons and minor skirmishes that forms a part of most childhoods, it is difficult to discount these and reduce them to a number. Secondly, the students were repeatedly assured that it was not an exam and that this assessment would not appear as part of their term report. An analysis of each question and what it tests is given below

Group Question 1 – It was meant for collaboration and communication.

Group Question 2 – It was divided into 3 sub questions – to check the STEM Literacy, Critical thinking and creativity.

Individual Question 1 – It was meant to check their ability to understand and analyse.

Individual Question 2 – It was meant to check their ability to evaluate and think critically.

Individual Question 3 – It was based on ethics to check decision making and application of ethics

Question No	Learning Skills	Literacy Skills	Life skills	Social Skills
GQ1			Y	Y
GQ2	Y	Y	Y	Y
IQ1	Y	Y		
IQ2	Y	Y	Y	
IQ3		Y	Y	

Table 1: Questions Analysis

The test was administered as an open book test with free access to notes, textbooks etc.

At this age children find it difficult to collaborate and are more self-cantered. It is expected that group marks would be lower. It has been possible to peer into the minds of at least

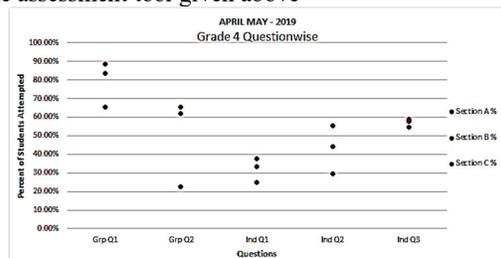
some students unlike in a standardized CBSE type test or the end of chapter questions. A few examples are given below

Some students have shown change in attitude and perception. They have become very much open and expresses their views nicely. Like Gurasees (4A) became very good at problem solving. Yogit (4B) - last year he was not ready to write in the assessment and that has changed. Rishit who appears to be naughty in class is very collaborative in group and thinks critically. There are few students who are very rigid, though they perform well in the class, they understand things but many a time they are not open to write their point of view. Might be they are stuck between right or wrong – like – Siraj (4B), Rajya (4C). Shabd (4C) thinks a lot and takes a lot of time in communicating. He finds it difficult to adjust to new situations and found the assessment very challenging being used to from the text questions.

6. Results and conclusions

The data has been taken and analysed in terms of class average and standard deviation.

First presented below are the question wise averages of the assessment tool given above



Given below are the score averages section wise for

Fig 4 Question wise average scores

group and individual separately

Score Measure	4A	4B	4C
Group average	13.0	23	21.5
Group SD	4.2	3.9	4.1
Individual Average	10.3	15.3	13.6
Individual SD	6.9	5.4	5.4
Total Average	11.6	19.2	17.6
Total SD	5	3.6	3.9

Table 2: Scores analysis(out of 30)

..The above data shows a diversity between sections. It also shows within sections the divergence is lower, the scores indicate clearly an understanding of the questions (verified from written answers too) and a concerted effort to attack the questions

The data clearly shows that the assessment was successful as the class average was high considering that these skills are not taught in class but had been learned through hands on activities. In terms of Blooms Taxonomy we are really looking at higher order skills only. Since the assessment is open book, the element of “remember” is not being assessed at all.

In conclusion the research question has been answered. The method given here is one way of assessing 21st century skills which has worked on this sample. The instrument has successfully captured the learning. At this grade level we expect a progressive building of 21st century skills which would be examined in further assessments of the same class

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