

Topic: Computational Thinking based on Geometry of Vegetables

A case-study of 3030 STEM program episode

Adithi Iyer, Akash Umaraliya, Ashutosh Bhakuni, Dinesh Rathod, Gaurav Yadav, Jay Thakkar,
Jyoti Gupta, Manish Jain, Sarita Yadav, Satish Kumar, Tapas Hira
Center for Creative Learning
IIT Gandhinagar
Gandhinagar, India
cli@iitgn.ac.in

Short Abstract

In this paper, we discuss basic conceptual understanding and critical thinking of mathematics and science using vegetables. This content was broadcast live on youtube¹ as 3030 STEM and was viewed by over 10 Lakh² viewers. Overall, the 26 episode online series had over 1 crore² view count. Prime focus of 3030 STEM was to:

- Unlock the hidden mysteries, beauty and magic in Maths and Science that is all around us,
- Make the curriculum more engaging, as suggested by National Education Policy 2020.
- Make science and math education experiential and hands-on

Vegetables and fruits like cucumber, carrot, okra, sweet lemon, and potato were used to study shapes like cylinder, cone, pyramids, spheres, and cube. Non-intuitive hands-on activities, like the peel of a slant cut on a bottle gourd forming a sinusoidal curve with area equal to π , area of a circle on a sweet lemon and on a flat plane being equal, making three equal volumed pyramids from a cubical piece of potato, gave the viewers a sense of wonder. Itempool³ was used to have a live Question and Answer type of interaction with the audience. The episode also contained open-ended homework/ assignments problems like carving out a 3D shape from a cucumber which looks like a triangle, circle and square when seen from different views. The engagement graph in Fig 4 shows that illustrations, live activities, stories, and homework problems can make online learning and teaching equally engaging and interesting.

Section 1 Background:

With the support of C.B.S.E and Vigyan Prasar, we at Center For Creative Learning, IIT Gandhinagar, conducted an online program - 3030 STEM. It aimed at discovering the beauty in Mathematics-Science and nurturing the inherent curiosity by engaging in hands-on activities. The pandemic bound students and teachers to their homes, and learning shifted from direct to the remote mode. Hence engaging the students became more challenging. Keeping in mind the suggestion of NEP 2020 about the use of Mother tongue /Regional Language, we conducted the one-hour sessions in Hindi for better understanding.

¹ <https://youtu.be/2aEGg5TMdHs>

² This count includes the raw YouTube videos multiplied with the average number of people watching from each device or account, as determined from a poll conducted with the participants.

³ <https://itempool.com/ccl/c/2We79fhvIOP>

During the two seasons of the program, we broadcasted 26 episodes live on Youtube every Sunday. Instead of going from subject to object, in the episodes, we choose an object as a theme and explore various concepts in the curriculum in an interdisciplinary manner. These objects included a bicycle, candle, A4 paper, vegetables, water, cricket, etc. A total of 75 thousand homework submissions and over 10 lakh comments from participants shows that students and teachers can be made more interested in math and science by designing hands-on activities from objects around them.

Section 2 Implementation

Content design plays an essential role in making classes engaging and interesting. Our years of experience of conducting over 150 workshops with 10,000+ teachers and 50,000+ teachers prompted us to keep in mind the following three dimensions while designing the outline of the session:

- Breaking the subject boundaries and approaching the curriculum in an interdisciplinary manner. For example, we explored topics like Trigonometry, Calculus, Geometry, Sustainability, Nutrition, History, etc., using vegetables like cucumber, sweet lemon, lady finger, carrot, and potato.
- Relating subjects with things in everyday life by hands-on activities, for example, understanding the projection of the earth's surface into a map using a sweet lemon.
- Provoking a sense of wonder through stories and non-intuitive questions, thereby making an impact in our lives. For example, the story of Archimedes and his findings that a circle on a sweet lemon and a flat surface, both yield the same surface area, is very non-intuitive and gives a sense of wonder.

This section illustrates the content in more detail:

1. Sine wave in peel of the bottle gourd:

- When we take a cylindrical piece of a bottle gourd, make an oblique(slant) cut across it we get an ellipse. Now, on removing its peel, we get a sinusoidal wave ($1 - \cos(\theta)$ to be precise, considering the base radius and height as 1). The area of this peel is π which is the same as the base circle of this piece. Now, on cutting off the upper half of this gourd peel, we get a piece whose area is independent of π and exactly equal to 1, which is non-intuitive (Fig 1(b)).



Figure 1(a): Sine wave from the peel of slant cut bottle gourd

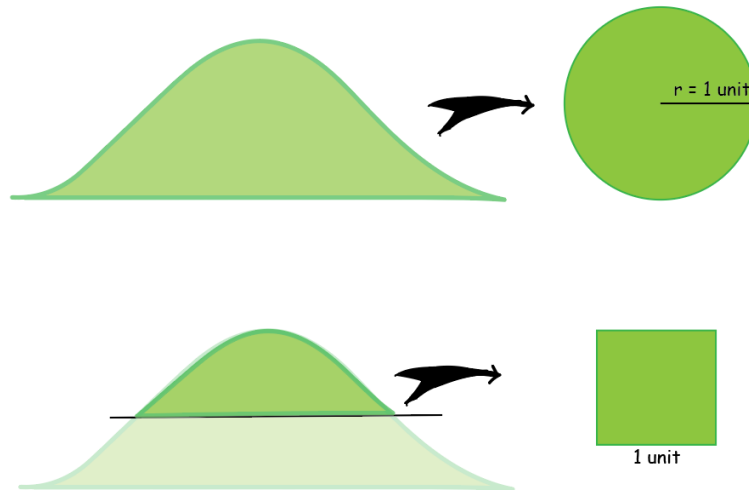


Figure 1(b): Appearance and disappearance of π from the area of peel

- Now, if we make a cut from the middle of the base circle, we get a piece whose volume and area are independent of π . The fact that the area of a piece from a cylindrical solid is independent of π gives a sense of wonder to the audience. Such non-intuitive activities make us think critically about concepts using computational thinking.

2. Volume of pyramids using Cross-section of a potato:

- Different cross-sections of a cube carved from a potato give various polygons i.e., triangle, square, pentagon, and hexagon. A visual illustration⁴ showing formation of a regular hexagonal cross-section, was followed by an open-ended question of making a regular pentagonal cross-section if possible or proved otherwise.
- In the curriculum, we have studied that the area of a pyramid is one-third the area of a cube through pictures of how these sections could be made. A puzzle of actually dividing this potato cube into three pyramidal pieces of equal volume gave everyone a hands-on practical understanding.
- A lady finger could be used effectively in a classroom for visualization of pyramids with pentagonal and hexagonal pyramids. Tasks of looking for and finding lady fingers with heptagonal, octagonal, or any other polygon as a base motivated students to observe what they eat and extend a helping hand in the kitchen.

3. Map distortion and comparing surface areas of cylinder-sphere using sweet melon:

- Visual comparison of countries like Greenland and India in a 2D world map shows ambiguity in areas. This suggests that projections are distorted when taken from a sphere to a plane. A visual module and a live itempool question compared the actual areas of a country on a globe and on a 2D map. The story of Archimedes gives a very non-intuitive way of understanding this distortion. This is done by proving that the peel

⁴ <https://www.geogebra.org/m/hawhwybp>

of slices of equal heights of a sphere has the same area irrespective of their latitude. These activities help us compare the actual area in the 2D projection of a globe. Additionally, the area of these peels is equal to the area of the peel of the cucumber/ Bottle gourd with the same base radius and equal height.

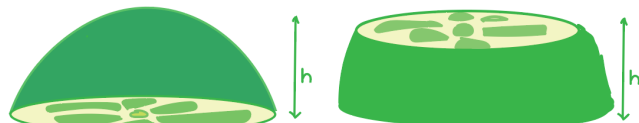


Figure 2: Slices with equal height of the sweet melon has same surface area

- Another hands-on activity shows that the surface area of a circle on a sweet lemon is equal to the area of a circle on a flat surface. This activity can be used to derive the surface area of a sphere.

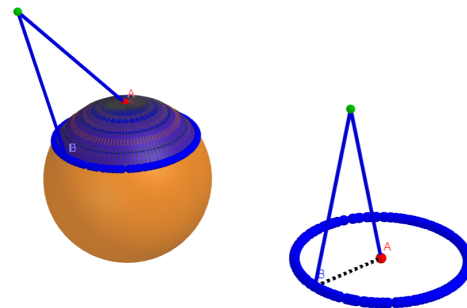


Figure 3: Circle on a sphere and on a flat surface

4. 3d geometry and visualization using cucumber:

In 3D visualization of solids, high school students study how a solid will look from different directions. We tried to make this visualization even more interesting through a homework problem⁵. We asked the viewers to carve a 3D structure with three different shapes when viewed from three different directions, i.e., front, side, and top view. The feedback and answer submissions to these questions showed how creativity inspires learning.

⁵ Gardner, Martin. "Mathematical Puzzles and Diversions. The Second Scientific American Book." *Academic Medicine* 37.1 (1962): 84

Hardware Setup:

The minimal hardware requirement for conducting such sessions is a mobile phone and stable internet connection. However, we conducted the program for a large audience, and to have a full HD live stream on Youtube, we used an advanced hardware set up. This setup included a computer, two cameras, one monitor, a writing tablet, a stable internet connection, a microphone, and appropriate connectors. The software used for the streaming was OBS⁶, which allows the presenter to switch between different cameras and even overlay different layers of content. For example, the video feed can be the background layer, and an image, a file, or a screen can be an overlay that can be resized. This allowed the delivery to be highly interactive.

Section 3 The Analysis

Viewer Analysis:

The registration count for the 3030 STEM program at the time of writing this paper was 5+ lakhs. The youtube analysis of concurrent viewers shows 100% engagement during the live session of the “Math in Vegetable” episode, as shown in figure 4.

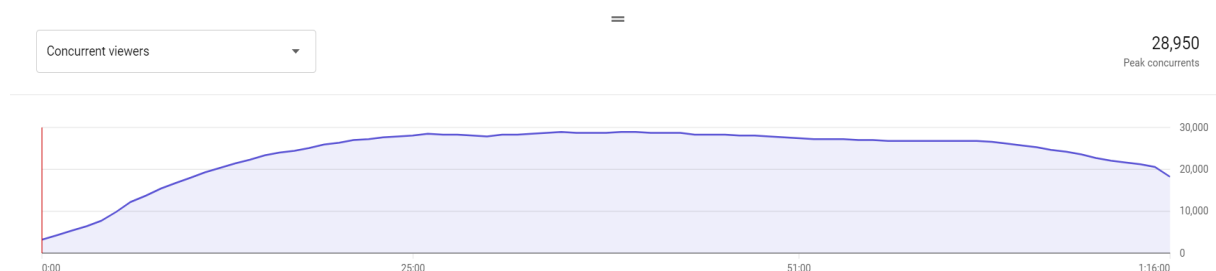


Figure 4: Engagement graph of viewers from YouTube analytics for vegetable math episode, 3030 STEM program

The average view time of this episode is 10 mins which is exceptional for an educational session. The data shows that the audience today has an attention time of less than two minutes. Participants' feedback shows how they think about a problem for days and the sheer joy they get from getting an answer. This suggests that stories, real-life context, object-oriented and thought-provoking sessions, and interesting homeworks can bring back the true fun of learning. The quantitative data from YouTube analytics and the feedback, shows the success of these techniques.

Section 4 Conclusion

The overwhelming engagement and audience feedback of the episode shows that the online mode of learning could also be made engaging and interesting. This process of starting from a relatable object like vegetables and moving to the subject like maths, science, and history, triggers computational thinking. Our experience of working with teachers and students to develop hands-on activities, indicate that these

⁶ <https://obsproject.com/>

techniques of designing a lesson and activities could help achieve the interdisciplinary approach giving learners a space to explore.

Annexure:

Homework Submitted - Puzzle of carving out a shape so that it looks like three shapes from different directions:



Feedbacks of Participants:



AMEER ALI • 10 hours ago

रविवार का इंतज़ार तो बेसब्री से रहता है कहने की जरूरत नहीं।लेकिन इस सप्ताह का टॉपिक "सब्जी में गणित "जब से पता चला तो हम सोचने लग गये कि क्या होगा इस एपिसोड में।पर आपने तो पृथ्वी की बहन मौसम्मी को ही ढूंढ लाये।आपने दैनिक जीवन और आसपास से इतनी बारीकी से सब्ज़ी से गणित को जोड़ दिया।आपने सोच को एक नई दिशा दी है,हम अपनी शिक्षण योजना में इसे शामिल करेंगे।बहुत बधाई आपकी और पूरी टीम को।





योगेन्द्र शास्त्री निर्मोही <yogendrasnirmohi@gmail.com>

to 3030

नमस्ते जी,

पिछले कई सप्ताह से आप सभी शिक्षकों के ज्ञानवर्धन के लिए जो प्रयास कर रहे हैं, वे अत्यंत सरल सुगम सहज एवं सराहनीय हैं जी। कल "सब्जियों में गणित" यह विषय अत्यंत रोचक, मनोरंजक, आह्लादक रहा। इसकी जितनी भी भूरि भूरि प्रशंसा की जाए, कम है। सब्जी को काटने की जगह संवारना बुनना तैयार करना आदि शब्द सुनकर बहुत अच्छा लगा जी। गणित सीखने सिखाने की परंपरा ऐसी भी हो सकती है, अद्भुत। मैं भविष्य में जब भी गांधी नगर आऊंगा आपसे अवश्य मिलूंगा जी। धन्यवाद:

१। नन्हीरा:

Respected Sir

Myself Ashma Sriram from The Air Force School, Delhi. To be very honest when we got mail from school that CBSE want us to enroll for STEM 3030, then at that moment I thought why science teacher, Maths teacher should be asked for that. But I enrolled and for Episode 1 through CBSE site I was not able to understand how to proceed. Then my colleague gave You tube link. From that kagaz ki Kahani till date not missed any of your episode. In fact when season 1 ended kept waiting for Season 2.

Now it's not only me but my son who came to class x used to wait for this programme and remind me every Sunday morning. Not only this, even your Item pool song was liked so much that most of the time I find him playing that on keyboard.

Seeing so much enthusiasm in him as a child, I request you to talk to many more students of our school and bring gleam in their eyes too. As a teacher in classes I teach I always used to talk to students about this programme.

Ashma Sriram

Respected sir/madam,

With due respect I wish thank the entire CCL, Gandhinagar team for creating such praiseworthy and knowledgeable content which aimed to bring back gleam in the eyes of children.

I myself was in grade 12, when I came to you about this program through one of my school teachers. Right from the beginning of the Season-2 I started following the episodes on regular basis. But, due to regular evaluations conducted by the school, I wasn't able to submit the homeworks well in time.

But, since the board examinations are cancelled now, I completed and submitted 10 homeworks (submitted last 3 today).

Surbhi Sharma

Amazing as usual....Aaj aise laga ki hum phir zinda ho gaye...Yeh episodes nahi the to jaise jaan hi nahi thi; bas mechanically sab kuch kar rahe the. Aj ka episode dekhkar phir jaan aagayi.Utsaah badh gaya..Of course homework dekhkar neend ud gavi, magar use kaise solve kare, iske vichaar dimaag mein shuru ho gaye.Solve karne ke baad jo aanand milta hai aur jo satisfaction milta hai use shabdo mein bataana mumkin nahi. Ek baar solve ho jaaye to bilkul chotte bacchon ki tarah uchal kud karne ka man hota ..hai!!!!It is that level of satisfaction.Falling short of words to thank you.

Sneha Binde