Engagement, Authenticity, and Exploration: Learning From a Postal Interaction in Reaching Out To Students

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Abstract

The overall goal of science outreach is to kindle interest in science and science careers. Prior research has shown that interest in science activities manifests in participation. This research was carried out in an extracurricular science and mathematics project in India when teachers and students did not engage with the learning materials during the pandemic. Teachers attended online workshops but the lessons were not reaching the students. Through a postal initiative, we offered support to the teachers and students. We received responses that showed engagement and learning. This paper analyzes the aspects of the learning that was taking place in this postal initiative. The study has implications for preparing learning material that students can use independently. The possibilities for further research and limitations of postal initiative with the aspects of lessons that worked for distance learning in science are discussed.

Keywords: science education, outreach, education initiative, exploratory science

1. Introduction

When the schools shut down due to the COVID-19 pandemic in early 2020, educators faced the task of making the shift from face-to-face to remote teaching. There were reports in the media that schools were struggling to maintain the momentum of educating students in this new remote mode. In India, schools provided teacher training for conducting online teaching as everyone grappled to make the transition to remote work. There were many issues reported in the online classrooms including disinterest among students. One of the bigger issues was accessibility (Onyeaka et al., 2021). In India, we learned from teachers that almost one-fourth of the students in their classes did not have access to networks or their own devices. While there were calls for change in the education system during this pandemic (Erduran, 2020; Fullan, 2020), there was also a need to look at the education delivery system (Onyeaka et al., 2021). We report from a science and mathematics project that had come to a near standstill at the school level during the pandemic. Teachers were supported through online workshops but they could not conduct the project activities. Through the postal mode, the project planned to revive activity with the students as well as reach those who did not have electronic devices or internet facilities. There are studies that discuss the issues raised by a global epidemic and the losses in learning caused by school closures. This article shares the findings on the forms of participation and interest that emerged as the outcomes of science learning communicated via postal methods. The study analyzes the features of learning materials that enable distance learning, and make exploration and learning possible even in the absence of continued teacher supervision and support in the teaching of these topics.

2. Literature review

2.1 Science outreach and outcomes

Typically science outreach programs are conducted by bringing scientists into the classroom to interact with the students, and by arranging laboratory visits for students (Tsybulsky, 2019), creating electronic and social media content, and initiatives by universities and museums inviting students and conducting science learning (Mackay et al., 2020). The objectives of science outreach programs are to scale scientific literacy and to increase inclusivity in science careers (McCauley et al., 2018; Tsybulsky et al., 2018; Varner, 2014), to change the outlook of students towards science and scientists positively (Mackay et al., 2020), and to collaborate with schools to improve science education (Tsybulsky, 2019; Tsybulsky et al., 2018). Outreach programs are considered impactful for the benefits they bring to the students' self-worth, their awareness of global issues, and public engagement skills that ordinarily wouldn't happen through a typical science classroom curriculum. Students' positive experiences (reported in Tsybulsky, 2019) are indicative of the emotional benefits of outreach activities and increase their internal motivation toward science learning (Vennix et al., 2018). In addition to all the positive outcomes, an outreach can nurture students' commitment to science learning, which is a good attitude towards science to cultivate among students (Tan et al., 2021). Among literature on informal learning provided by outreach, there is evidence of benefits from opportunities for learning in science museum programs (e.g., Franse et al., 2021; Gutwill & Allen, 2009; Piqueras & Achiam, 2019; Shaby & Vedder-Weiss, 2020) but few studies provide insights into non-exam-oriented science learning at home. There are studies in India that discuss the impact of the pandemic but not many that explore student interest and the outcomes of doing science outside of regular class hours.
Science outreach improves students' perception of efficacy in science education and their interest in pursuing "an undergraduate degree in a science-related field" (Diamond, 2020, p. 2). Interest can shape students' perceptions about a subject, providing a natural motivation for participation in activities related to the subject (Ainley & Ainley, 2011), and leading toward a commitment to lifelong learning in that subject (Alexander, 2004, cited in Ainley, 2006). Interest may be evidenced in a subject through participation and effort (Ainley & Ainley 2011;

Jonas, 2011). Self-efficacy and aspirations are measurable outcomes of interest over prolonged exposure to science learning, but forms of participation in the immediate teaching-learning situation can be helpful indicators of student involvement. Participation may be evidenced either in terms of attendance in the classroom, extracurricular activities, doing and turning in assignments, attitudes toward school, teacher-student relationships, and belongingness (Ainley, 2012). During the pandemic, it was challenging to keep students engaged with online learning. Some educators suggested using materials easily available at home for doing science might make the exploration more engaging and productive (see Morgan, 2020).

2.2 Engagement

Interest results in student engagement, which is an 'immersed' state of participation with the learning material (Ainley, 2012). Engagement is essential to learning and student achievement. It has hence been studied extensively. Student engagement has been defined in various ways. Engagement has been defined as a construct with multiple dimensions, namely cognitive, emotional, and behavioral (Fredericks et al., 2004). Student engagement has been conceptualized at micro and macro levels, and this determines how engagement is studied (Sinatra et al., 2015). A micro level perspective observes signs of student's engagement in the activity while a macro level would focus on learners in the classroom, school, or community (Sinatra et al., 2015). Engagement has also been studied in different situations other than the context of school subjects (see Linnansaari et al., 2015). In this study, we consider the behavioral aspects of persistence and effort in defining engagement. Engagement is indicated by the involvement, focus, and persistence in tasks, and needs activities that are of interest to students (Ben-Eliyahu et al., 2018). There are various ways in which science activities can be designed to deliberately ensure student engagement. Student engagement can be observed in activities that involve developing explanations and solutions (Inkinen et al., 2018). Engagement is also related to students' perceptions of being able to complete tasks. Students are known to engage with learning material if they perceive efficacy in those tasks (Yang et al., 2021). Processes of engagement are hence useful for evaluating whether students can work with such learning material in distance education, and if they are of sufficient interest to students. Persistence and effort in working with the learning material would be indicators of engagement in this study.

2.3 Authenticity

Authenticity in science education has been defined in different ways. Murphy et al. (2006) conceptualized authenticity in terms of personal and cultural authenticity. According to Murphy et al. (2006), when specific scientific practices like designing experiments are built into learning, the tasks represent the cultural practices of scientific work. This is a common definition where the emphasis is on constructing tasks so that the students are getting an

experience of how scientists work (see Sandoval, 2003; Ford, 2008, 2012). Personal authenticity of the task for the students is the relevance seen in the task of doing experiments as meaningful to the students (Murphy et al., 2006). Learning becomes meaningful when the learning context is not different from using science (Levinson, 2013; Lee & Grace, 2010). Archer et al. (2018, 2021) and Rivera Maulucci (2010) argue that science learning becomes meaningful when the students can relate the learning to their own contexts and their contributions are valued. Social justice framework underpins the teaching-learning processes that make students feel that their social contexts and cultures are valued (Rivera Maulucci, 2010).
In this study, the task materials require students to conduct small experiments, measure, and observe. The selected materials were based on local context such as exploring rice varieties, local soil, nutrition choices, cleaning copper with different materials, and understanding wood ash. This feature of the tasks exploring scientific practices bears authenticity to science practices even when the tasks are done at home. Definitions of science authenticity such as those involving scientific practices as seen in Ford (2008, 2012), Murphy et al. (2006), and Sandoval (2003) limited to the professional aspect of doing science. Drawing from Archer et al. (2018, 2021) and Rivera Maulucci (2010), we ascribe authenticity in the ability to draw from local culture and practices, use their local terms, and learn about local histories.

2.4 Exploration

Exploration is a key aspect of doing science but it is hindered in school practices in many ways. Use of textbooks and laboratory manuals limits the exploration of concepts or materials (Yager, 2015). In a classroom, the teacher provides scientific names and information when introducing new natural objects or phenomena. This early transmission of information can hamper students' verbalization and exploration (Singh et al., 2019). Singh et al. found that when students were left to explore outside of the classroom, they freely explored the flora around them and were engaged in giving descriptive names to plants which they could not identify. Allowing students spaces in which they can bring their diverse knowledge from their own home cultures helps identification with science learning (Archer et al., 2018, 2021). In the classroom, the teachers can make small changes so that students feel that their knowledge is valued (Archer et al., 2018, 2021). Students also need more opportunities for exploring their methods of problem-solving and voicing their own experiences which are possible if tasks are more open-ended and have a "loose pedagogical structure" (Oliveira et al., 2021, p. 3). Exploratory activities when done out-of-school or in home environments bring about curiosity, affiliation with friends and family, and a positive relationship with science (Zimmerman et al., 2019). In this study, we looked for indications of exploration and tried to identify tasks that might have limited students from exploring. We consider tasks limiting if the students need more discussion and guidance which may not be possible in distance learning.

3. Method
3.1 Background

The data for this study is from a smaller initiative within a large-scale project in science and mathematics education in India. The project aims to nurture interest in the two subjects. The project has 43 learning materials called Learning Units developed by scientists, mathematicians, and teachers collaboratively. These learning materials are meant for grades eight and nine students but the teacher may conduct these lessons with students of lower or higher school grades. The learning materials have activities on different topics in science, mathematics, and local context. Learning materials for the postal mode were chosen in consultation with the teachers. The topics for the postal outreach were related to studying varieties of rice, diversity in soils, cleaning copper, food choices, and the nature of wood ash. Each of these lessons begins with checking students' prior understanding of concepts. The tasks require students to carry out small experimental explorations. For example, comparing the effect of sandpaper and household soaps on copper. Most of the materials needed for the activities can be found in school laboratories and are safe for students to work with.

We were doing online workshops with the teachers during the lockdown. We took the postal initiative to involve students who were left out of online classrooms. In this way, we could also support some of the teachers in ensuring student participation in the project. The initiative began small with just three project members (also authors of this paper) and a few interested teachers. We requested the teachers to check with those students who had limited or no internet access whether they would be interested in doing science and mathematics activities at home. We checked if teachers would find ways to deliver the worksheets to the students or if we should send the worksheets directly to the students. Two of the teachers asked us to send the materials to them and forwarded them to the students. Other teachers checked with the students and shared the home addresses with us to mail the material to the students. In the mailed worksheets, a list of alternatives was provided as substitutes for items such as litmus paper that is not available at home. A consent form was attached to the first worksheet that was sent. We sent a stamped envelope to facilitate the easy return of completed worksheets. Teachers could help by talking to the students remotely and providing them with initial direction on working with the learning material. We received 91 worksheets at the time of this study (see table 1).

Table 1: Number of participant schools, teachers, and lessons.

Schools	Teachers	Lessons	Copies sent
8	9	9	119

3.2 Analysis

We have followed Hsieh and Shannon's (2005) summative qualitative content analysis. Completed worksheets were segregated from blank or incomplete ones. Coding was done only for completed worksheets. We have coded and interpreted 64 completed worksheets. Worksheets were read first, followed by marking similar answers and unique answers. Students' response data was coded for use of the personal pronoun, description of the task, and uniqueness of answers displaying signs of their involvement in doing the experimental activities. Use of local language, local terms, and culture-specific knowledge were also coded. These codes show how the students were drawing from their personal and home experiences. Table 2 shows the frequency of the codes against the completed worksheets received from the students. We have stated numbers rather than percentages because in some cases the numbers are so few, a percentage might not present a real picture. The codes are categorized under the themes of engagement, authenticity, and exploration.

4. Findings

Table 2: Frequency of occurrence of each coding category (in numbers, indicating the code category evidenced against total number of worksheets received).

Units based on	Use of personal pronoun	Description	Unique	Local language	Local terms/ knowledge	Completion	Blank or incomplete
Soil	23/26	22/26	26/26	8/26	-	26	1
Rice	7/7	5/7	5/7	5/7	5/7	7	-
Copper	11/12	10/12	10/12	5/12	3/12	12	1
Wood Ash	4/4	3/4	4/4	-	-	4	-
My food	2/7	7/7	7/7	-	-	7	-
Volume	2/8	2/8	3/8	-	-	8	4

In the following analysis, all the student data are anonymized. Students are identified with their initials and their school number. For example, SC01SJ is a student from school number 01 and the initials of her name are S and J.

4.1 Engagement

Written responses from the students showed differences in the usage of material and their explanations. Most of the experimental tasks listed several materials that students could choose from depending on availability. Students have used local substitutes for some of the materials in experiments. The variation in materials produced different results for the students. The difference in responses shows that these were not answers students wrote after checking with each other but based on their observation and understanding. For example, in the lesson on exploring local soil, one of the tasks begins with a story about Dr. Buchanan-Hamilton's discovery of laterite in India. Dr. Buchanan shared his discovery with the British government. The students are asked why he shares his discovery with the government. To the question following the story asking why Dr. Buchanan shared his discovery, here are some of the student responses-

> Dr. Buchanan found it interesting because laterite dries fast. It dries soon after cutting and becomes hard as a brick. It resists water much better than any other type of brick. - SC03PS
>
> It is full of cavities and pores, and contains a large quantity of iron. - SC01DY
>
> Dr. Buchanan found the soil interesting because it contains cavities and pores, and a large amount of iron. - SC01PK
>
> Dr. Buchanan wrote about the red soil to the British government so that the government may know about this indurated or hardened clay that can be used as one of the most valuable building materials. - SC01VT
>
> He found laterite soil as the best building material that could be made at a very low cost. It could be used as a construction material without firing in furnaces like clay bricks. He found it more durable as compared to any other building and construction material. Laterite soil was easy to cut into brick-like shapes for use in monument buildings. - SC01RM

Some of the students have used a few words from the story passage itself or paraphrased. There is a positive outcome in students voicing their answers irrespective of the correctness. Some answers in the typical classroom may be incorrect and they often go unvoiced because of the fear of ridicule. The last two responses (SC01VT and SC01RM) show that those students have understood the true reason for Dr. Buchanan to share his findings. The intended learning was to realize the significance of discoveries for economic and political reasons, which is not the standard line of classroom discussion regarding scientific discoveries. Most textbooks in India provide discoveries as an intrinsic reward for the scientist's work, and do not discuss the political and economic implications of some discoveries and inventions. Those students who could not arrive at the intended outcome in this home learning could have benefitted from further discussion. We did a follow-up on such responses. Our follow-up questions were sent with the next worksheet. The students only sent us the next completed worksheet but did not reply to the follow-up, which was not very helpful.

We also evidenced engagement in persistence in the task or activity. For example, the lesson entitled 'My food, my choice' is about nutrition and exploring the possible influence of the media on our food choices. Students were expected to note the changes in storage of various cooked and uncooked food items. One of the tasks required wheat flour to be covered and observed over four days. Some students observed the wheat flour and reported there was no change in its color, appearance, or smell in the entire period. The student's observation of changes in wheat flour over four days is a sign of engagement. Observation over time is a habit to be cultivated as it helps students understand that discoveries are not 'instant'. Moreover, students did not give up when there was no change and followed the time recommended for the task.

4.2 Authenticity

Authentic learning was coded for responses that showed noticing surroundings, discussing and learning about local plants, soil, and food, learning about local practices, and using local terms for materials. Students provided answers that showed that they were noticing their surroundings. For example, they were noticing if the local soil was used for coloring, which is a feature of the soil perhaps seen every day but not noted before. The following excerpts are from responses to the question about color in local soil -

> Yes, the soil in our neighborhood is used to color houses. We find white, red oxide, black soil or manganese oxide, and yellow soil. These colors are collected in the form of lumps and powdered. They are then mixed with water and glue. Sometimes, they also add rice starch. - SC01VT
>
> Brown colored soil is used for painting houses in our village. - SC01RM

With the lesson on rice, students were learning about the local varieties of rice and how agrarian practices have changed over time. The students conducted surveys and learnt about the agrarian background of their respondents. The objective of this task was to help students make connections about the food that they consume and agricultural practices, an important aspect of sustainability education -

> *Q: Is the food you eat now any different from what you ate as a child? If yes, then how is it different and why is it different?*
> Yes, some foods have remained the same and some are different now because the environment has changed. That means human beings have changed practices. Back in the old days, we produced crops in ways that were respectful of the environment. But now people are growing a large number of crops and polluting the environment. -SC05MR

> Yes. In our time, rice used to taste nice. Nowadays, the same food is tasteless. Food is not grown naturally; they use heavy fertilizer and pesticides. -SC05B

Students also used local language terms in the responses. In the lesson on soil, student responses had local terms for different types of soil. They also named many varieties of rice that were indigenous to their native town or village in the lesson on rice. A student names some of the rice varieties that are found in the local shop -

> We have many rice varieties like *sonamasuri*, brown rice, *basmati*, and *rajamudi* - SC05SJ

Here *sonamasuri* and *basmati* are common varieties available in most states while *rajamudi* is native to the region to which the student belongs. In the lesson on cleaning copper, students had to explore the effect of different substances. The objective is to understand whether the change is physical or chemical, and the acidic-basic nature of substances. One of the students mentioned additional substances, namely dry mango and kokum (*Garcinia indica*), as suitable for removing the tarnish from copper. The student learnt about the regional use of dry mango and *Garcinia indica* in his hometown.

4.3 Exploration

The intended outcome of exploration was achieved in the lessons sent to the students. Students were found to respond more to lessons based on rice, soil, cleaning of copper, and understanding wood ash. The exploratory lessons such as the ones based on soil or rice invited different responses through open-ended questions, and that may have given greater freedom to students. For example, a student used paper dipped in turmeric instead of litmus paper. In another lesson, most students used locally available ash for testing in the lesson on ash. Ash is a product of burning local wood, and ash found in open areas may be mixed with other substances. Therefore, tests of acidity-basicity showed a variety of results. The substitution of materials and differences in the local material would show different results. There was hence no incorrect answer. Further, we claim students' descriptions as proof of genuine exploration and engagement because these students did not look up references for correct answers or check with each other like they usually do in classrooms. Students were free to express their results and we saw their personal descriptions. On the other hand, with the lesson on understanding volume, we found very few students returned completed worksheets. There is the possibility that students might have difficulty understanding some of the mathematical terms used in the worksheet even though the terms are explained. Students' uncertainty or lack of clarity when dealing with certain concepts such as 'percentage error' for the first time could have been reduced in a classroom discussion aided by a teacher. The option in the postal communication was to write explanations directly. We sent follow-up questions but some of the students did not respond, and instead turned their attention to the next lesson.

5. Discussion, limitations, and conclusions

Engagement and authenticity evidenced in student responses point to their interest in science, and their explorations show some degree of autonomy. Yackel and Cobb (1996) defined autonomy as a child's ability to participate in intellectual activity relying on their assertions and not that of an adult authority. In this study, through language use and original answers, the students have provided proof of their autonomy. There was no extrinsic reward associated with participation in this initiative. 91 students turned in their responses, showing more than a three-fourth section of participants' willingness to engage with the lessons. Thus, students have shown a willingness to participate and therefore, interest (Ainley, 2012). Teachers are always challenged in classrooms to find ways to keep all students proactively engaged (Nagro et al., 2019) whereas this analysis finds that given an opportunity to explore, students kept the correspondence going. This proactive turn of students sending in responses via mail shows their interest in doing science independently, providing evidence that engagement requires suitable activity (Ben-Eliyahu et al., 2018). Students' responses have been considered important forms of engagement because not all responses were correct and yet they were 'voiced'. While whole class discussions are opportunities for student talk, some voices often go unheard and unnoticed (O'Connor et al., 2017; Lefstein et al., 2011). This postal outreach facilitated individual answers within a safe space. The initiative of reaching out to students via the postal method kindled interest in students who did not have internet access, thus achieving the intention of including students disadvantaged by the pandemic. Authentic learning opportunities answered the needs of the students which made them keep the correspondence going. This shows that social justice science helps develop a greater commitment to learning (Rivera Maulucci, 2010).

Looking closely at the responses qualitatively rather than relying only on the numbers tells us which contexts have facilitated engagement and exploration. This study shows the engagement of the students in lessons with more open-ended questions. Flexible answering options thus likely increased their self-efficacy resulting in better engagement (Yang et al., 2021). Students had the opportunity to bring their local knowledge through the use of local understanding, language, and use of substances, which made the learning more authentic (Archer et al., 2018, 2021). They had opportunities to develop solutions from materials within their local context, thus resulting in engagement (Inkinen et al., 2018). When compared with the lessons that required measurements and needed teacher intervention, lessons that allowed students to explore freely, i.e. loose structure, found more responses from students (Oliveira et al., 2021).

We are aware of the challenges of remote work that we are trying to overcome. Some responses indicated that the child may have not understood clearly, or the child's responses should have been heard in the whole class and would have provided rich fodder for discussion. We wrote to the students as follow-up activity but students moved on to the next worksheet. A learning that we take away from this incident is that follow-up should be completed by waiting for students to write back and then the next lesson may be dropped.

This initiative showed some implications in creating activities and lessons for distance education. Correspondence for education began with postal services (Casey, 2008) and may have become almost obsolete, but this method even today offers some insight into what might interest students. The findings in this study have come from a small study with few school students. If this outreach were to be scaled, research might reveal further insight into students' particular interest in science topics because student responses emerge in those tasks and activities that are connected to their needs (Sullivan, 1979; Swirski et al., 2018). In this study, we had sent lessons in consultation with the teachers. Future research can compare teacher recommendations on what might interest students and students' perceptions.

Notes:

Learning Units are available on the project website - https://vigyanpratibha.in/index.php/learning-units/

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Conflict of Interest

We have no conflict of interest to declare.

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