IMPLEMENTING NGSS THROUGH STEM INTEGRATION

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Table of Contents

Curriculum Topic:

Implementing Next Generation Science Standards (NGSS) Through STEM Integration

School background, Teacher PD Participation

LEAD Elementary is a Title 1 public school in the San Mateo Foster City School District that services 524 pre-K through 5th grade students. The student body is 64.5% Hispanic, 10.1% White, and 9.2% Pacific Islander, with 71.4% receiving free or reduced lunch and 67% classified as English Language Learners. There are 24 full-time certificated employees, 23 are teachers. The school offers a classical education program with an emphasis on literacy.

The district adopted the NGSS standards two years ago and is currently going through a science curriculum adoption process, with the goal of piloting a new NGSS-aligned science program for the 2019-20 school year for all elementary schools. Our district has not formally provided professional development opportunities that explicitly focus on the standards and how they can be incorporated into daily instruction. The 2019-20 school year is the first year 5th grade will be tested in science. Currently, teachers are encouraged to collaborate with each other to identify and implement best science practices into the literacy-based curriculum.

The participants in the professional development included teachers from all grade levels as well as an RSP teacher. The school leader did not participate but did observe the PD. There was a total of 18 employees, or 75% of our certificated staff in attendance for this optional PD.

Standards Addressed in PD

3 - 5 K - 2

3-PS2-1 Plan and conduct an investigation to provide evidence of the effect of balanced and unbalanced forces on the motion of an object.			**K-PS2-1** Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.		
Science & Engineering Practices ~ Plan and conduct an investigatio	**PS2.A Disciplinary Core Ideas** ~ Each force acts on one	**Crosscutting Concepts Cause and Effect** ~Cause	**Science and Engineering Practices** ~ With guidance,	**PS2.A Disciplinary Core Ideas** ~ Pushes and pulls can have	**Crosscutting Concepts Causes and Effect** ~ Simple

n collaboratively to produce data to serve as the basis for evidence, using fair tests in which the variables are controlled and the number of trials are considered. **NOS** ~ Science investigations use a variety of methods, tools, and techniques.	particular object and has both strength and direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion.	and effect relationships are routinely identified.	plan and conduct an investigation in collaboration with peers.	different strengths and directions. Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it.	tests can be designed to gather evidence to support or refute student ideas about causes.

ELA/Literacy -

RI.3.1 Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers. *(3-PS2-1)*

W.3.7 Conduct short research projects that build knowledge about a topic. (3-PS2-1)

W.3.8 Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories. (3-PS2-1)

Mathematics -

MP.2 Reason abstractly and quantitatively. *(3-PS2-1)*

MP.5 Use appropriate tools strategically. *(3-PS2-1)*

3.MD.A.2 Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l). Add, subtract, multiply, or

ELA/Literacy -

W.K.7 Participate in shared research and writing projects (e.g., explore a number of books by a favorite author and express opinions about them). (K-PS2-1)

Mathematics -

MP.2 Reason abstractly and quantitatively. *(K-PS2-1)*

K.MD.A.1 Describe measurable attributes of objects, such as length or weight. Describe several measurable attributes of a single object. *(K-PS2-1)*

K.MD.A.2 Directly compare two objects with a measurable attribute in common, to see which object has "more of"/"less of" the attribute, and describe the difference. (K-PS2-1)

	divide to solve one-step word problems involving masses or volumes that are given in the same units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem. *(3-PS2-1)*	

Summary of Professional Development

This professional development opportunity began with a pre-survey through Google forms. I surveyed the teachers to determine their level of comfort for the NGSS standards and STEM - based lessons. I found teachers were interested in learning more about how to interpret and apply the NGSS standards in the classroom. Teachers also showed an interest in learning more about STEM integrated lessons.

I obtained permission and support from my school leader to offer a 1-hour optional PD opportunity. We began by deconstructing the NGSS standards for each grade band for approximately 10 minutes. Teachers experienced a hands-on learning activity following the deconstruction of the standards for approximately 30 minutes. Teachers explored assets through Google Classroom that supported the hands-on activity for about 15 minutes. Finally, teachers completed a post-PD survey in Google forms.

Pre-PD Questionnaire and Key Findings

Of the 24 certificated employees, 13 responded (54%) to the pre-survey questions, which are listed below. Key findings were that generally teachers do not feel confident implementing the NGSS standards. Teachers generally do not incorporate the Engineering standards or STEM integrated activities in their classrooms.

- **Will you attend the PD?**

  100% replied “yes”

- **How would you rate your familiarity with the NGSS standards?**

  53% - “Not as familiar as I’d like to be”
  46% - “Somewhat familiar”
  0% - “Very familiar”

- **In addition to the Disciplinary Core Ideas, how often to do you implement Crosscutting Concepts (CCC) and Science and Engineering Process Standards (SEP) into your science curriculum?**

  7.7% - “at least once per week”
  7.7 - “2 to 3 times per week”

38.5% - “Never”
46.2% - “Every other week”

- **Do you have access to NGSS-aligned resources in your classroom?**

  30.8% - “maybe”
  38.5% - “No”
  30.8% - “yes”

- **How often are you including STEM or STEAM based activities into your classroom?**

  7.7% - “I conduct STEM/STEAM activities once per week”
  15.4% - “I conduct STEM/STEAM activities at least twice a month”
  61.5% - “I conduct STEM/STEAM activities infrequently”
  15.4% - “I have not conducted a STEM/STEAM activity in my classroom”

- **Do you have NGSS-aligned STEM/STEAM activities you would like to share with the staff?**

  0% - “yes”
  69.2% - “no”
  30.8% - “maybe”

- **Would you be interested in more PD opportunities that demonstrate how to incorporate STEM/STEAM activities into your curriculum?**

  100% - “yes”

Description of the PD Training

The professional development took place during our weekly teacher planning time on March 6th, 2019, from 1:30pm to 2:30pm. Eighteen teachers and staff participated. The session was guided with a power point (see appendix) and opened with a discussion of the NGSS standards for which the activity was aligned. About 10 minutes was spent on deconstructing how to read and interpret the two sets of standards, with an emphasis on how they represent what we want our

students to be able to do and understand after a lesson or unit of study.

Teachers then experienced a hands-on activity where they had to predict, make, weigh, and measure paper airplanes for mass differential and distance traveled. The hands-on activity was differentiated for each grade band; k - 2 and 3 - 5. Teachers were able to experience the lesson from a student perspective. During this process, there were many opportunities for turn and talks. Highlighting the use of turn and talks to build and form new knowledge was demonstrated as a technique to help English language learners extend content knowledge and vocabulary. The hands-on activity was meant to be completed in 20 minutes but teachers really enjoyed the opportunity to build and test their airplanes so the activity continued for an additional 10 minutes.

The teachers were asked to finish up and return to their table groups where they went into Google Classroom to explore documents and links designed to extend and elaborate on forces of flight. The interactive pHet simulations were paired with worksheets to further elaborate and build academic knowledge. The NASA assets were paired with opportunity to reflect and refine content knowledge by pairing them with written reflections in student interactive notebooks. Teachers were also able to further their capacity for understanding the NGSS with a link to a brief on the 3 dimensionalities of the standards.

Finally, teachers were able to review some formative and summative assessment tasks that give students opportunity to demonstrate their takeaways post lesson. Last, teachers completed a post-survey to assess the effectiveness of the PD and to determine where we might focus in future PDs.

Brief Outline of the Activities

1-hour optional PD centered on an NGSS aligned STEM lesson over forces and motion with the goal being to demonstrate how to integrate NGSS through STEM based lessons.

1. Whole group deconstruction of NGSS standards on force and motion for k - 2 and 3 - 5

    a. Purpose of DCI, SEP, and CCC and how these are applied to a lesson introducing and exploring force and motion
2. Hands-on paper airplane activity and how it relates to the NGSS standard
    a. How activity relates to Common Core Math and literacy objectives
3. Review available assets
    a. Explore interactive pHet simulations through Google Classroom
        i. How we can extend our knowledge using models
    b. How we can leverage technology
        i. Explore NASA cross-curricular assets and database through Google Classroom
        ii. How to incorporate literacy and writing in our investigation
        iii. How we can leverage technology
    c. Link to targeted brief on the NGSS standards
        i. How teachers can expand their knowledge using briefs
    d. Links to grade level specific NGSS supplied lessons
        i. Collaborating by sharing tested resources
    e. Links to formative and summative assessment tasks related to the hands-on activity
        i. How students can demonstrate their knowledge
4. Post survey questionnaire in google forms
    a. Gathering feedback to inform our next steps in building capacity for NGSS through STEM integration

NASA Data Included

The goal of the PD was to demonstrate how to integrate the NGSS standards with other curricula using a STEM based lesson. The NASA data I chose for this k - 5 PD hit the literacy standards outlined in the standards addressed. Teachers were able to explore *NASA Knows* for k - 4 and 5 - 8. K-4 has a wonderful story on airplane forces that can be read to the students using the microphone option or students can read it on their own. I shared with teachers that students can record 3 - 5 things they learn about forces in their interactive notebooks. The *NASA Knows 5 - 8* story has more advanced vocabulary and is a great way to differentiate for the different grade bands. It is also a great way to bring in technology. Finally, I shared *NASA's Best* with the teachers. Most of these lessons are hands-on lessons that also integrate Reading and Writing with Science, Math, Engineering, and Technology.

Follow up Activities

After reviewing the post survey responses, it is clear that teachers want more PD showing how to effectively use the NGSS in conjunction with STEM based lessons (that also incorporate our literacy standards). Since I do not have the market cornered on the best PD to meet this challenge, I have reached out and partnered up with a local program, Curiodyssey, to put together future PD's that will address the need.

Curiodyssey currently pushes onto campuses in my area to provide 3 STEM based science lessons for 3rd, 4th, and 5th grades. I met with the program director and we sketched out 8 future professional development opportunities that will be teacher driven. 4 of the opportunities will be administered just like the PD I offered; optional and based on NGSS STEM integration within the context of our literacy program. We plan to present the other 4 opportunities as teacher-driven cohorts that will focus on specific teacher concerns/interests that come out of the 4 major PDs. Myself and/or a member of Curiodyssey will present the cohort PDs. The optional cohort PD opportunities will follow after a major PD and also be on Wednesdays, during teacher work time. Major PD topics will center on what the teachers are interested in learning more about within the context of NGSS and STEM integration. This will be determined by google forms surveys. This is the outline of my plan to continue to lead the way in providing teacher-driven meaningful opportunities to build capacity for NGSS and STEM based integration.

Post-Questions Survey List from 18 attendees

- **What did you find LEAST useful in this PD?**
  - Carrying out the sample experiment because I have already done it before
  - I wish we had a little more time to collaborate with colleagues/align vertically
  - n/a
  - The extended readings on the website are a bit challenging for my grade level.
  - Need more time/series of lessons to collaborate!!!
  - It was a little rushed at the end, it would have been great to be able to really go through each segment of the lesson and spend more time in the components of the lesson rather than the resources at the end. We can look at resources on our own time.

- Nothing
- Nada, it was great!
- I liked it all.
- I found engagement piece of the lesson least useful. I think you could've banged that part out faster so that you can get to the meatier stuff (not in the real classroom, but just here).
- It was all great!
- I wish we had more time to collaborate with other grade levels.
- n/a
- None, it was very informative.
- The specific lesson on lift (but could be modified for RSP)
- L.S "hmmmm"
- E.M. "unsure"

- **Do you feel more comfortable with the NGSS standards?**
  - 60% - "yes"
  - 47% - "maybe"
  - 0% - "no"

- **Would you like information on more STEM activities?**
  - 100% - "yes"
  - 0% - "maybe"
  - 0% - "no"

- **How would you like STEM activities information provided?**
  - Through Google Drive
  - The Google Classroom site is a great place for us to store our info as a school
  - email, please
  - On the shared website or through more PDs or PLC type meetings =)
  - staff meetings, e-mails, buddy activities to practice these (I'm lucky to buddy with you!!!)
  - Email or google drive
  - Electronically
  - I love that you gave us a shared space via the google classroom.
  - Lesson examples, more PD, shared docs
  - More PD's together!
  - In google classroom
  - Email, links to resources, low prep ideas for STEM activities.
  - Another PD/ google shared folder
  - Shared through Google drive or Google Classroom.
  - Email or shared classroom page. Thank you, Deanne!
  - L.S. "I'd love to be included on a Google Drive resource share

- E.M. “online - google drive, staff site?”

Data Analysis

I filtered through the open-ended responses looking for key words such as; content, assets, resources, and reference to specifically named resources such as “NASA” and “simulation”. In doing so, I found 72% of the attendees stated the content was the most valuable takeaway in responding to the question, “What did you find most useful?” This corresponds to the 100% “yes” response rate to the question, “Would you like more information on STEM activities?”

I filtered through the open-ended response to the question, “What did you find least helpful?” to evaluate teachers’ perceptions of my pedagogical approach. I found 22% of the respondents made a recommendation to change portions of the PD related to pedagogy or disliked some aspect of it. For example, one respondent stated, “I found the engagement piece of the lesson least useful …” This speaks to the pedagogical approach I used. Another respondent stated, “Carrying out the sample experiment because I have already done it before.” Again, this speaks to my pedagogical approach to use a specific hands-on activity, among all activities related to forces and motion.

Was the Professional Development Successful?

Overall, I felt the PD attendance was a success. Because PD is optional in my district, I was concerned that I might not get 12 or more attendees. I think the buy-in was teachers liked the idea that it was given by a fellow teacher as opposed to someone outside our campus. I also feel teachers appreciated the fact it was not mandatory.

The PD content proved to be very meaningful as outlined in most of the open-ended responses. I was aware through conversations with staff that many teachers felt unprepared to explicitly use the NGSS standards as opposed to the previous California Science Standards. I was also aware that our district has not reached the vast majority of elementary teachers in terms of providing them with ample PD opportunities for familiarizing themselves with the new standards through the lens of lessons and

activities. Bringing the PD to a personal level (campus initiated) really helped overcome the usual obstacles of district offered PD.

From a pedagogical approach, this was my second time conducting a PD for my campus and I must say it is intimidating! I think the overwhelming positive responses I received however, are egging me on to continue shaping our campus culture toward a meaningful professional learning culture by and for our teachers for the benefit of student achievement outcomes. In this way I also believe we can build teacher capacity for a more integrated approach to our curriculum.

How Did This Project Relate to the Readings?

> Desimone, L. (2011). A Primer on Effective Professional Development. Phi Delta Kappan, 92(6), 68

Desimone outlines “common features … of effective professional development that are associated with changes in knowledge, practice, and … student achievement”.

- Content focus: PD should focus on subject matter content and how students learn that content. My PD was content focused for aligning state mandated standards to a STEM based lesson on forces and motion.
- Active Learning: Teachers should have opportunities to get involved, such as observing and receiving feedback, analyzing student work, or making presentations, as opposed to passively sitting through lectures. My teachers were engaged in an activity through the lens of students.
- Coherence: What teachers learn in any PD activity should be consistent with other PD, with their knowledge and beliefs, and with school, district, and state reforms and policies. The PD was set against the backdrop of state mandated standards and grade level content.
- Duration: PD activities should be spread over a semester and should include 20 hours or more of contact time. The initial PD was an hour. I am currently putting together additional future PD on the same broad topic. Although my current outline falls short of 20 hours, I think we can extend it to or beyond 20 hours throughout the next school year.
- Collective participation: Groups of teachers from the same grade, subject, or school should participate in PD activities together to build an interactive learning community. This is the impetus of my pursuit for more professional development. I believe we can build to a reform

for integrated instruction if we continue to explore integration of NGSS based STEM curriculum that can be easily adapted to our literacy reform efforts.

Kaniuka, T. (2012). Toward an understanding of how teachers change during reform: Considerations for educational leadership and school improvement. Journal of Educational Change, 13:327-346. DOI 10.1007/s10833-012-9184-3

This case study resonated with me because my campus is in the process of a literacy reform protocol that is district mandated. Kaniuka explores the relationship between teacher capacity and school reform. According to Kaniuka, teacher capacity, which is defined as the teacher's ability to make effective school reform decisions, is experiential. (328). School reform refers to the schools' ability to successfully impact student achievement outcomes based on teachers' abilities to make effective school reform decisions. Basically, a circular argument. With teacher capacity being experiential, if teachers' past reform experiences have not been successful, ie., the reform efforts did not achieve the desired outcomes, teachers may not be motivated to make changes in their own habits of teaching or changes in beliefs about their students' performance abilities. This being the case, any current reform efforts may be nullified.

The case study shows how teacher capacity was changed as a result of sustained ongoing professional development opportunities around the literacy reform effort. The ongoing support the teachers received as they implemented stages of the reform had an overall positive outcome for teacher capacity and a positive outcome for teacher belief in student ability. Simply put, teachers bought into the reform and urged it on while developing their own capacity for the new literacy program.

Sustained professional development resulted in building teacher capacity for a new literacy program. I think that a similar outcome for building teacher capacity for NGSS aligned STEM integration can be achieved at my campus by offering sustained PD opportunities throughout the 2019-20 school year. As stated earlier, the current sketch falls short of the recommended 20 hours as outlined by Desimone. However, my school leader is supportive of my efforts and I am confident we can increase the contact time to the recommended 20 hours.

Reflection

As outlined under “follow-up activities”, I plan to conduct more informal PD opportunities focusing on building teacher capacity for NGSS standards-based STEM integration. I believe the PD went well as evidenced by the open-ended post survey responses being mostly positive. However, there is the possibility that survey questions may not have been explicit enough to be reliable or I may not have had enough cross-referencing questions for the responses to be reliable. I think that I could spend more time building my own capacity for using polling tools more effectively so as to elicit more reliable information in preparing for future PDs.

I also felt like I was pressed for time. I think there was too much content to cover in an hour. I struggled with balancing the amount of content against the time. One attendee felt like it was rushed and suggested in post survey that resources could have been viewed individually and after the PD. I wish I would have thought of this myself. I could have given the link to teachers before the actual PD and we could have spent more time evaluating how to implement the lesson or more time on deconstructing the standards. These are things I will definitely consider in future PDs.

Appendix

- Presentation ppt link
- pHet simulation forces and motion basics
- NASA Knows k - 4 link
- NASA Knows 5 - 8
- NGSS brief
- NGSS lessons provided - Grade 1 Grade 2 Grade 4 Grade 5
- NASA Best k - 5
- Assessment Tasks - below

My Airplane Recording Sheet K - 2

[Airplane Formative Assesment 3 - 5]

[Aircraft Forces Label and Explain K - 2]

[Messin Around with Forces pHet Simulation wksht 3 -5]

[Messin Around with Forces Reflective Questions for NASA digital story]

[Airplane Lab lesson 5E model]

Artifacts

Pre-PD Survey Responses: Time Stamps

2/23/2019 8:13:00	TK
2/24/2019 20:12:23	K
2/24/2019 22:22:00	4
2/25/2019 9:49:19	2
2/25/2019 15:06:03	5th
2/25/2019 21:57:19	K
3/1/2019 12:41:13	5
3/6/2019 6:50:34	K-5 RSP teacher
3/6/2019 7:36:49	Kindergarten
3/6/2019 7:44:45	2 through 5
3/6/2019 7:54:37	4th
3/6/2019 8:54:58	3rd
3/6/2019 11:00:17	1

Responses by grade level:
Pre K - 1
K - 3
1st - 1
2nd - 1
3rd - 1
4th - 2
5th - 2
Other - 2

Post-PD Survey Responses: Time Stamps

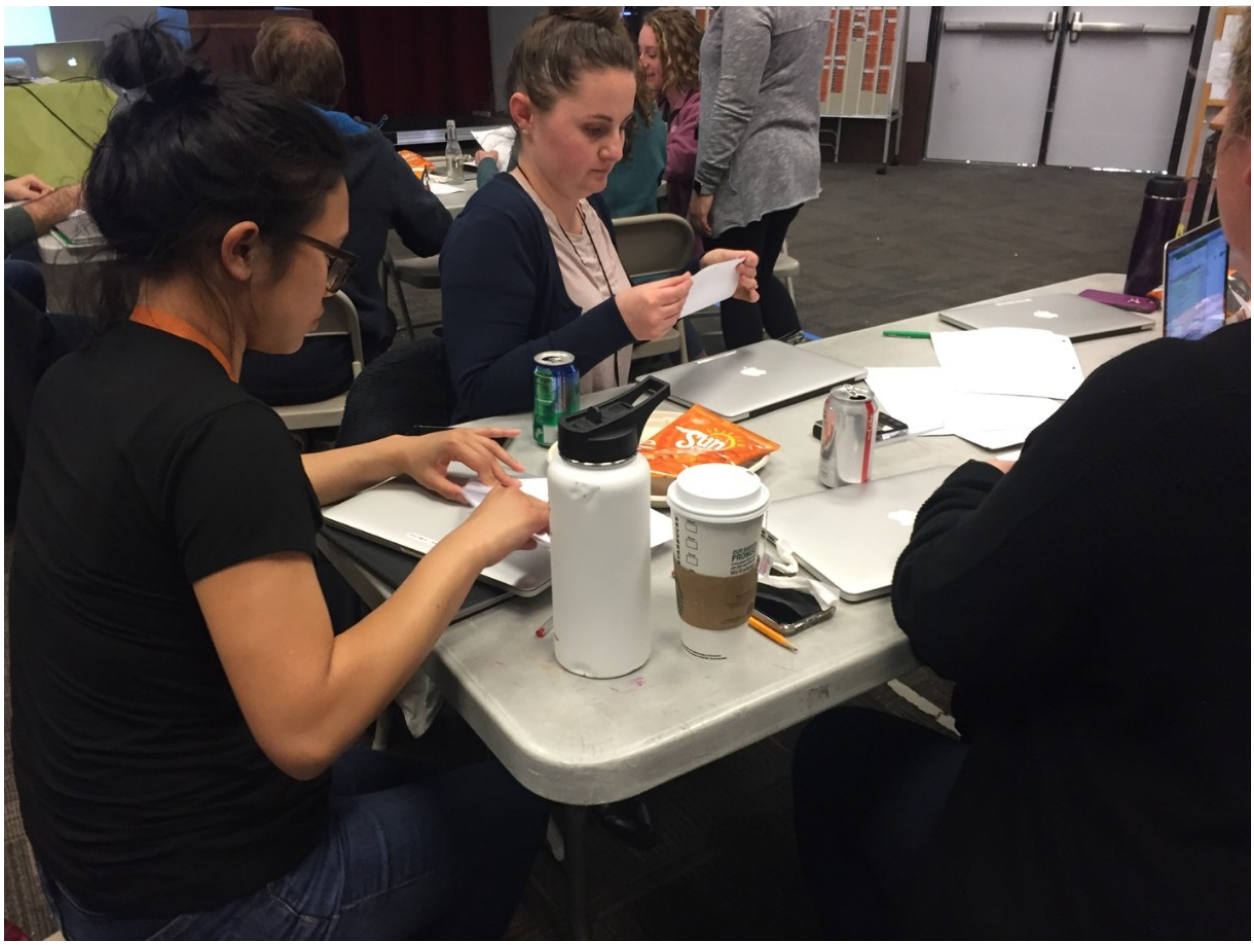
Timestamp	What did you find MOST useful in this PD?
3/6/2019 14:27:21	The assets on the Google Classroom site
3/6/2019 14:27:25	The lesson plans were already created and ready for me to use
3/6/2019	reminder about asking purposeful questions, setting students up to come up with

14:27:48	questions
3/6/2019 14:27:52	The activity simulation, and examples of class discussions and recording sheets related to the activity.
3/6/2019 14:27:54	the online resources and google classroom
3/6/2019 14:28:28	Simulation lesson with the engage and how that connects to the activity
3/6/2019 14:28:30	Interactive experiences with the NGSS
3/6/2019 14:28:42	The shared classroom was fantastic! It was great to see all the components that you can add and the resources you choose to include.
3/6/2019 14:28:57	I loved the launch of the activity. I liked being walked through the standards and then through the lesson. It was great to see what it looks like.
3/6/2019 14:29:01	I found the resources posted, as well as the chance to explore them, most helpful.
3/6/2019 14:29:42	grade level specific examples and ideas
3/6/2019 14:29:49	Providing content that is accessible for all grade levels and for all academic levels.
3/6/2019 14:29:59	The chance to go through a lesson as a student and see how it's framed. I also find the google classroom resources useful.
3/6/2019 14:30:36	Making a fun topic of folding paper airplanes and applying to NGSS to make science more accessible.
3/6/2019 14:34:13	Differentiated content accommodating literacy needs

L.S. and E.M. were not able to open the Google survey link and I am transcribing their written responses:
L.S. On line resources that were leveled and images.
E.M. Online resources.

Photos from PD


Coke


Sun


Did you drink your milk today?
got milk?
MAXIMUM OCCUPANCY 343 PERSONS
FIRE ALARM STATION
INSIDE THIS DOOR
RIGHT HAND SIDE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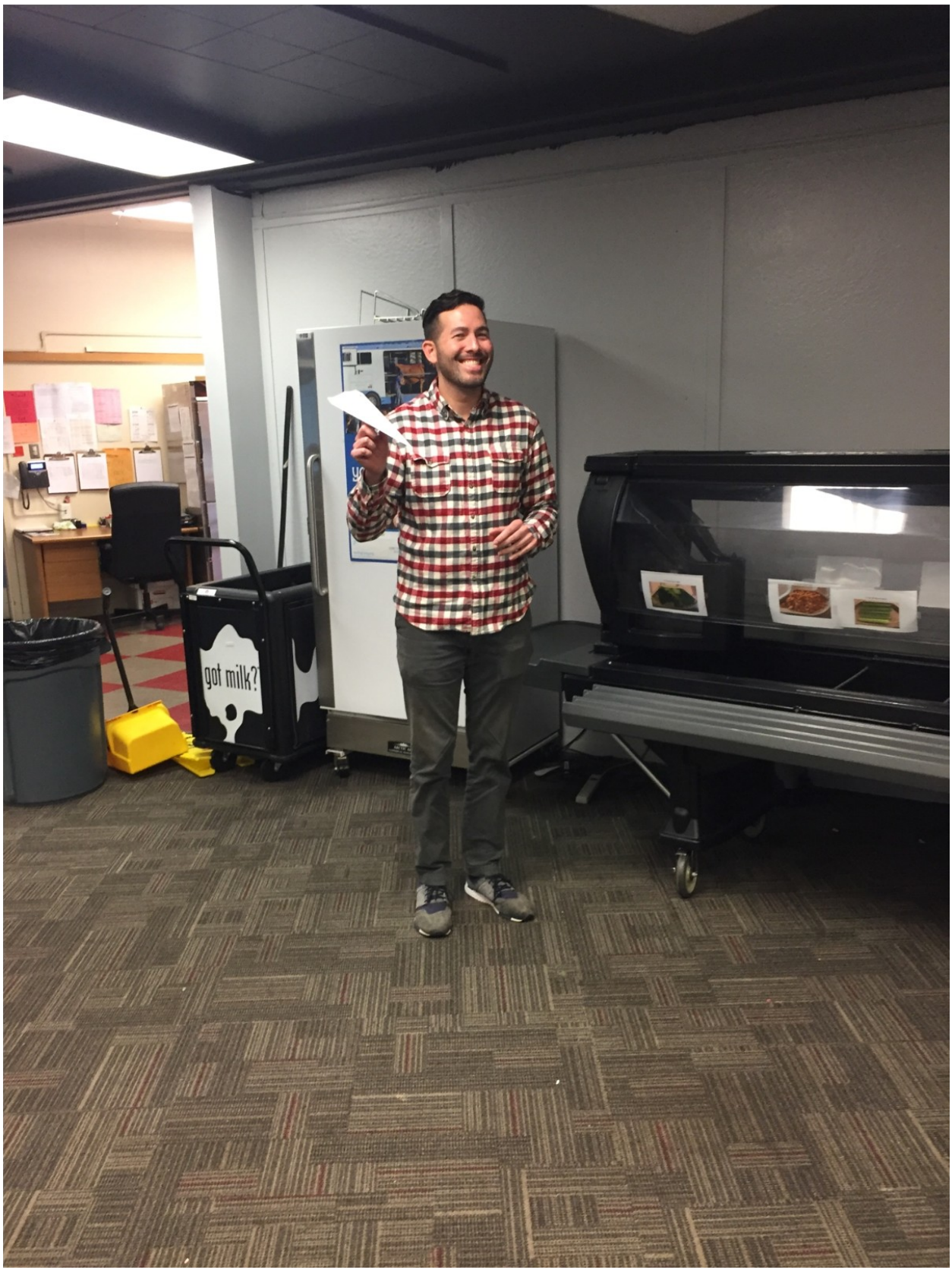
got milk?


EXIT


EXIT


EXIT