Teacher Professional Learning to Support Students' Motivation in NGSS Classrooms

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M-PLANS

Summary

The promise of the Next Generation Science Standards (NGSS Lead States, 2013) rests on teachers creating instructional experiences where students are highly engaged and active in their learning. We iteratively designed and tested a research-based professional learning (PL) approach to help middle school science teachers effectively support and sustain students' motivational competencies during ambitious science instruction. A team of researchers and middle school science teachers co-designed a PL approach called M-PLANS (Motivation - Planning Lessons to Activate eNgagement in Science). Early testing suggests promise for impacts on teacher beliefs and behavior as well as students' motivation and engagement in science.

Overview

- **M-PLANS** (Motivation - Planning Lessons to Activate eNgagement in Science) refers to a suite of professional learning tools to facilitate middle school science teachers' modification, creation, and implementation of instruction that supports students' motivation and engagement along with the science and engineering practices, crosscutting concepts and disciplinary core ideas specified in the NRC Framework (NRC, 2012) and NGSS.
- Co-developed with experienced middle school science teachers and school district science coordinators through a cyclical co-design process.
- Aim to create professional learning experience to equip teachers to support middle school science students' motivation using five theoretically- and empirically-based Motivational Design Principles (MDPs; Linnenbrink-Garcia, Patall, & Pekrun, 2016).
- Two primary research questions: (1) How do teachers respond to M-PLANS? and (2) How do students respond to instruction developed by their teachers through M-PLANS?

M-PLANS Development Cycle

2 cycles of implementation in racially and ethnically diverse districts in MI and NV:

- Phase 1: 6 teachers, 94 students
- Phase 2: 18 teachers, 323 students

- Teachers queried about the incorporation of the MDPs into their planning and teaching, the usability of the resources and tools, and how the program supported changes in their teacher-student interaction through focus groups, interviews and pre-/post-implementation teacher surveys.
- In each classroom, a small set of lessons were video-recorded so that the team could examine how MDPs were translated into practice.
- Students completed brief end-of-class surveys for video-recorded lessons and pre/post surveys querying them about their motivation and engagement as well as teachers' instruction aligned with the MDPs

Motivation Design Principles for Science Instruction

MDP	Design Principle	Sample Metacognitive Planning Questions
Belonging	Support feelings of relatedness and belonging within the classroom community and the larger science community by promoting inclusion and helping all students to identify with science	How does this lesson extend an invitation into science for all students? How am I connecting this lesson to my students' experiences outside the classroom and checking that I am not sending explicit and implicit messages about who does and does not belong in science?
Confidence	Support students' confidence for science through instruction that includes clear expectations; challenging work that is calibrated to the knowledge, skills, and abilities of students; and informational and encouraging feedback	What kind of specific feedback should I anticipate giving that will draw students' attention to strategy use and potential for improvement? How will I communicate that I believe every student is capable of doing the work? How will I encourage students if they perceive the assignment to be too challenging?
Learning Orientation	Emphasize growth in three-dimensional learning and understanding as the goal of science learning, rather than rote learning, grades, competition, or social comparison	What opportunities does this lesson provide for students to engage in challenging reasoning, making sense of phenomena, designing solutions, revising their thinking, and/or reflecting on their understanding?
Autonomy	Support students' autonomy through opportunities for student decision making and direction during science instruction, such as in the context of investigations of phenomena and solving problems	How can I challenge myself to promote student autonomy in this lesson in ways that enhance students' development as science learners? How will these autonomy supports help students make sense of phenomena and/or design solutions to problems in this lesson?
Relevance	Consider students' perspectives and provide science learning opportunities that students find personally meaningful, interesting, and/or culturally relevant	What is taking place in the world or local communities right now that I can draw on in relation to the phenomenon or design problem of interest? Are there opportunities to connect students' in-class learning to these current events or issues and/or give assignments an authentic context?

MDP in Action

These design principles were translated into a complete Toolkit through the co-design process. The toolkit includes:

- Multi-day PL to build background knowledge
- Resource Guide with sections on (a) supporting equity, (b) establishing a positive classroom climate, (c) MDP-specific resources [overview, look-fors, planning tool, activities, talk moves], (d) NGSS connections, (e) lesson planning tool
- Website with Resource Guide
- Quick Tools
- Peer mentoring guide
- Knowledge-in-use assessment
- Tools for gathering feedback and promoting reflection

Toolkit Elements: Examples

BELONGING TALK MOVES

- "Thank you for sharing, [name] - we should definitely talk more about this!"
- "Who wants to add on to what [name] said?"
- "The teamwork in here is impressive. You all worked so well together."
- "You all sound like scientists/engineers the way you are asking questions!"
- "I love to see how each of you thinks about [x]."

BELONGING ACTIVITIES

- Daily check-ins: Spend a few minutes talking about non-school topics with a different student each day; follow up if you notice something is wrong
- Include scientists/ engineers with diverse backgrounds in materials and/or displays
- Invite students to think about and share their ideas about how science could benefit their communities

Belonging Supports for Using Mathematics and Computational Thinking

Rationale

Applications of mathematics and computational thinking in science and engineering require flexible thinking in a variety of contexts. Instructional strategies that support students' feelings of belonging cultivate a safe space for students to take chances with potentially unfamiliar types of mathematical or computational thinking across contexts. Strategies that support belonging also encourage students to develop a sense of being part of a community of scientists and engineers, which is especially important for students who may not have a well-developed science identity or who may feel alienated from science [see ~~Motivation as a Tool for Equity~~]. As students begin to feel a greater sense of belonging within their science classroom community and within science and engineering communities, they may feel more inclined to engage in using mathematics and computational thinking as a practice.

Strategies

Provide opportunities for peer support by having students work in groups to brainstorm ways to organize data into a form that will simplify future calculations.

Science Stories: Adventures with Chemistry

Instructions:

In this booklet, you will read about several science stories. For each story, use what you know about science to answer questions about particles, reactions, and energy.

Some questions might be easy for you, but others might be hard. Read the questions carefully and try your best to answer each one.

Remember...

· We have included some hard questions on purpose.
· Don't get discouraged and try your best on each question!
· Your teacher will help you to keep track of time.

Name: ____________
Teacher: ____________
Period: ____________

This assessment is freely available for teachers participating in the MPLANS project to use in their classrooms, but it is not available for any other use, including commercial use (Creative Commons Attribution-NonCommercial 3.0 License). 1

SEP 1: ASKING QUESTIONS & DEFINING PROBLEMS

- **B**
  - Share examples of scientists from diverse backgrounds engaging in scientific questioning to help students develop their science identity
  - Provide opportunities for scientific questions to be heard through group work
- **C**
  - Model scientific language that students can use when asking questions and defining problems
  - Give students informational feedback on their scientific questions to help them improve
- **L**
  - Do a think-aloud in which the teacher models scientific question-asking about a phenomenon or models how questions lead to other science and engineering practices, such as analyzing data or planning investigations
  - Incorporate scientific question-asking as a reading strategy to normalize asking questions
- **A**
  - Use a Driving Question Board and encourage students to research questions that interest them
  - Affirm scientific questions or wonderings that students pose spontaneously in class
- **R**
  - Incorporate current or local examples of science phenomena so that students can generate scientific questions centered on issues relevant to the community
  - Invite students to bring scientific questions to class based on their experiences and observations outside the classroom

SEP1 HTTPS://M-PLANS.ORG/TOOLKIT SEP1

Belonging Planning Tool for Peer Mentoring

Teacher:	Date:
Mentor:	Link to M-PLANS Toolkit Belonging Resources

Guiding Questions	Notes
1. To what extent do this lesson's activities promote student voices/contributions, and how will you acknowledge and recognize these contributions such that students know that you value their voices?	

Key Findings

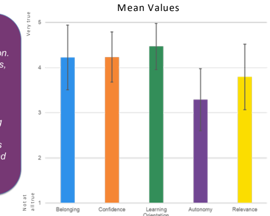
RQ1: How do teachers respond to M-PLANS?

Findings from observations, interviews, focus groups and surveys indicated that:

- M-PLANS PL changes teachers' knowledge about and use of instructional practices for supporting student motivation.
- Teachers shifted beliefs about motivation and engagement in science
- Teachers found the materials usable and useful
- Teachers used a range of strategies to implement each MDP suggesting that teachers were able to personalize the design principles

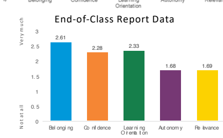
"This study enabled me to collaborate and network with experts in the field of education. Through classroom recordings, I was provided constructive feedback from experts, colleagues, and my students, which has empowered me to improve my craft by becoming more confident and knowledgeable in NGSS. This has truly been a rewarding and enlightening experience!"

Teachers' Knowledge and Use of MDPs: Mean Values



Teachers' use of MDP strategies were perceived positively by students, and there was variation across teachers.

End-of-Class Report Data



RQ2: How do students respond to instruction developed by their teachers through M-PLANS?

Regression analyses of pre-post survey data revealed changes in student motivation as a function of students' perceptions of teacher support for motivation.

Motivational Belief	Cohen's f^2 [a]
Perceived Competence	0.21
Intrinsic Value	0.12
Utility Value	0.25
Attainment Value	0.10
Mastery Goals	0.17
Belonging Need Satisfaction	0.27
Effort Cost[b]	0.14

a Cohen's f^2 effect size: small = 0.02, medium = 0.15, large = 0.35 (Cohen, 1988)
b Negative association between perceptions of motivation support and effort cost.

Conclusions & Next Steps

- Results provide initial evidence of promise of M-PLANS for supporting changes in teacher beliefs, knowledge, and practice with downstream impacts on students' motivation and engagement in science.
- Teacher feedback suggested that adding supports during teachers' early implementation of the MDPs could further strengthen the impact of M-PLANS. Next steps include (a) developing a dashboard to provide just-in-time feedback based on student end-of-class reports to inform teacher practice and (b) providing structured professional learning communities and opportunities for peer mentoring among teachers.
- Additional next steps include further knowledge mobilization through (a) PL opportunities for building and district administrators and (b) expansion of M-PLANS program to other grade levels and domains.

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