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# What is STEM Interest?

## An Interview with Nancy Staus

*On March 15, 2018, Kelly Riedinger, Senior Researcher at Oregon State University's Center for Research on Lifelong STEM Learning, interviewed Nancy Staus, to understand her thinking and work on the topic of STEM interest. Dr. Staus is a Senior Research Associate at Oregon State University in Corvallis, Oregon. Her research focuses on such areas of science education as the role of emotion in science learning, STEM learning in informal environments, and STEM interest development during adolescence. A video of Dr. Staus's interview, as well as interviews of other researchers, is available at InformalScience.org/interest.*

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### *What led you to study interest or to include it in your work?*

I've been working on a longitudinal project called Synergies in which we've been examining how STEM interest develops over time and in an underserved community in Portland, Oregon. The reason we chose interest as our outcome instead of something like achievement is that it's becoming clear in the research literature that interest in science and STEM is actually a stronger predictor of persistence, leading to STEM majors and even STEM careers, than are other outcomes such as achievement. That means that kids who are really interested in an aspect of science, math, or any other component of STEM don't necessarily do well in it at school—they don't always get good grades or don't score high on exams—but if they have a well-developed interest in that concept, their engagement can persist over time. It seems to be a very strong motivational variable for learners that can keep them going and wanting to learn more, and it can lead to some of the outcomes that educators hope that it will lead to, like STEM majors and careers. That's why we focused on interest rather than other measures. But we are also looking at other things like aspirations that are very much connected to interest.

### *Can you talk a little more about how you study interest in your longitudinal study?*

Our framework of understanding and conceptualizing interest was Hidi and Renninger's four-phase model of interest development. They showed that interest actually occurs in four phases, but there are two main phases, each with two parts. Just to simplify things, early interest is referred to as situational interest, and that can be triggered in a learning environment just by something novel or unexpected that grabs your attention. That interest is less enduring and needs a lot of external support in order to maintain it. However, once a learner has crossed the threshold into what we call individual interest, that's a more enduring, self-generated type of interest, and in that case the learner doesn't need a lot of support from outside people or environments. They have developed an intrinsic value for that topic or activity, and they're able to search out other resources to help them support and develop that interest.

Interest develops over time, and if you're going to study interest you do need to study it over time because it's constantly developing. Youth are going through these phases and they don't just go in one direction; they can also lose interest in things. In our study, we chose to follow youth through the adolescent years, through middle school, which is 6th through 8th grade in the school district we're working in, because the literature shows that this seems to be a critical time in STEM interest development. Youth are making decisions they may not even be aware of about the things that they're going to continue to be interested in and pursue later in life. Research has shown that there's a pretty steep decline in STEM interest during these years, so we wanted to follow a number of cohorts of youth to better understand the patterns we were seeing, whether the youth declined in interest, what factors seemed to be important in influencing their interest development and maintenance or non-maintenance of interest over those years. We're in the eighth year of a 10-year longitudinal study, and by the end of it we'll have five full cohorts of youth that go through middle school. The first five years was a research phase where we were understanding the system and getting baseline data. Now we are trying to influence the system and trying to use what we've learned to promote STEM interest development and maintenance over those years for more kids. We have been able to institute some learning interventions.

### *So in this study you're looking at two phases of interest development, situational interest and individual interest?*

Yes. Our study uses surveys, interviews, and observations, not just in classrooms but of activities outside school. These instruments aren't fine-grained enough to look at all four phases, but we're pretty successful at seeing the difference between kids who have a situational interest in science or STEM and those who have moved beyond that. It looks like there's a threshold that kids need to get over, because the situational interest is so externally motivated—others are really supporting it and keeping the learners engaged—whereas once youth have moved into that individual interest phase, it's really self-driven. You can really see a difference, especially in interview data, in kids who have a situational versus an individual interest. The ones with the individual interest are really go-getters; they're really looking for the next thing to do that supports their interest.

### *What are the other two phases of the interest model?*

It's sort of nested. Within situational interest, which is the first large phase, there's *triggered situational interest* which is pretty short-lived. Imagine you go into chemistry class the first day and your chemistry teacher does this amazing experiment where things blow up. That might trigger a situational interest: you're thinking "oh wow, oh chemistry's so cool." That could only move into the next phase of situational interest, which would be *maintained situational interest*, if the teacher did more things throughout the class to keep kids interested enough that they wanted to learn the content. Triggered situational interest can dissipate pretty quickly if there isn't a lot of external support and motivation to keep the kids going. In contrast, *emerging situational interest* is somewhat self-directed. A kid with emerging situational interest might go home and look up a website on how to do that experiment and maybe try to do it at home and blow up their house or something–which may not be good. Those phases are really characterized by a need for external support. Meanwhile, once you move into individual interest, *emerging individual interest* is the first phase, and that moves into *enduring individual interest*. Those are the phases that are most likely to correlate strongly with persistence in STEM and those outcomes we were talking about earlier—majoring in STEM, going on to STEM careers—because those are really self-generated. Those learners who have maintained an enduring individual interest will seek out the resources and information they need to support that interest. They will learn more about it, so it's characterized not just by affective emotional factors like they really like it and feel positive about it, but also they have much more knowledge about the topic. They may become sort of amateur experts and just really know a lot about the topic that they're interested in. The topic has a lot of value, it's very relevant to them. And they increase in self-efficacy. They feel that they are good at that subject or activity, that it's something they can do and that they can show others how to do. Interest is kind of multidimensional; it's a pretty complex concept because there are affective and cognitive factors that are working together, but then the amount of each factor changes over time as learners go through different phases of interest. For example, situational interest is very affective and emotional. It's very much, "oh, I really like that, you know?" And it just sparks excitement about the topic or activity. Meanwhile, the individual interest phases are characterized a lot more by cognitive components, a lot more knowledge, value, and self-efficacy for that topic. Most of that is self-generated at that point and the learners don't need a lot of support from outside people or institutions.

### *What are some findings or tidbits you've learned about interest through Synergies?*

I think one of the really salient points about interest research that science educators should keep in mind is that interest can only develop through those phases from situational to individual through the ability to reengage with the topic or activity over time. There have to be opportunities for the learner to keep doing those activities. This is where it gets hard in school environments to support interest development from situational to individual interest. For example, in 6$^{th}$ grade the kids in Synergies undertake an astronomy unit at school which they just love. In the survey, 60% of kids say that was their favorite unit, they love astronomy, they want to be an astronomer now, so it's very much a strong triggered situational interest in astronomy. But the unit lasts a few weeks and then of course the teacher has to move on to the next topic in the curriculum. Here are all these youth with triggered situational interest and they need to reengage the content—where do they go? It's really important, I think, for classroom teachers to understand that and to have something in place. Maybe if there's an astronomy club, at the end of your unit have the astronomy club leader come in and talk to the kids: "Hey, if you're really interested in this why don't you come to my club next week?" Or if there's already a science club or some sort of afterschool activity, maybe the teacher could talk to that facilitator and say: "Hey, my kids are really interested in this topic. Could you do something that would help them reengage in astronomy?" There needs to be a lot more communication among educators if we are going to value interest as a learning outcome as much as we do achievement on tests. We're going to have to change some of the systems that are in place so that we can really support that development over time.

### *What are the interventions you're doing with Synergies to help learners reengage?*

We survey youth at the middle school, 150 or almost 200 kids per grade every year. So we have a pretty good understanding of what kids are interested in and excited about, and we share that information with the teachers and tell them, "These are the things that youth are interested in; you might want to offer some resources." In addition, the middle school we work at has a Schools Uniting Neighborhoods (SUN) coordinator. This is a full-time person whose job is to locate afterschool programs and bring them to the middle school so these kids have access to them. They don't even have to be STEM programs. We actually worked a lot with her, and she was willing to work with us, which was great. We showed her our data and said, "This is what we're seeing kids are interested in," and we had already gone out in the community and found some potential afterschool partners that we could suggest to her. For example, a lot of kids like to do science experiments with volcanoes and exploding things, so we were able to help bring in 4-H Science Club, which lets kids do those sorts of things. A huge majority of kids love coding, programming, and video games, and Pixel Arts Game Education is another afterschool club we were able to help bring in so kids are able to develop and support that interest. We also have a Girls Who Code class for girls who don't want to be in a coed coding class for a variety of reasons. It allows them to still have access to that and feel comfortable in that environment. There's also the Mathematics, Engineering, Science Achievement (MESA) Program, which allows kids to do building and engineering projects, which are also really popular in that age group. We were able to be really intentional about the afterschool programming that we helped to bring to the school. We've also been working with those partners. Our grant is a research practice partnership, so we are working with our partners as participants in our research and sharing our research results with them—what we're finding in terms of interest development. We're working with them to try to better customize some of their offerings to speak to the kids in our community, since their interest may be a little different from that of kids in other communities in Portland. That's been really successful and we have quite a lot of interest in the kids each year; the number of kids participating in these activities is increasing. It's been very positive for the community.

We are going to survey them again in 10th grade and 12th grade. We will try to keep interviewing them as they get older, but it's not easy to keep them interested in talking to us. So the numbers of kids will probably drop off a bit as they get older, but we do hope to get a better sense by 10th and 12th grade of their future aspirations, in terms of a college major or what they want to do as a career. We want to correlate their STEM interest, see how it changed over time in middle school and see what that looks like in terms of future aspirations as they get older and are about to enter either college or the workforce.

### *What's your working definition of interest, and how does that differ from other definitions of it?*

There are a number of different theoretical frameworks for studying interest. It cuts across different disciplines: psychologists are looking at interest in a certain way, neuroscientists have looked at interest in their way, and educators have looked at interest a little simplistically as kind of "liking," focusing more on the affective or emotional factors, which really is just part of interest. Over the last few years, science educators and researchers have been incorporating a lot of the psychological literature, which I think is a strength now, particularly Hidi and Renninger's four-phase model of interest development and the factors they have found that either help support movement from situational to individual interest or not. So we're thinking about it as a multidimensional construct and we're measuring it in a large-scale survey with a lot of kids participating, as well as a smaller number of interviews and case studies, which really add richness to our understanding. In the survey, we are asking questions that pertain to both the affective, the liking or attitudinal portion of interest, and also the cognition part, their knowledge of a topic. "How much do you know about this, how much do you value it? What's your self-efficacy level in STEM?" We're trying to look at all of those different parts of interest development at the same time and then fleshing it out with the interview data, which also helps us understand how kids are finding or not finding the resources in their environment that allow them to support their interest development over time. That portion of the research in the first five years of Synergies was really important when we started working with the school to locate the kinds of afterschool programs that we thought would be most beneficial for those kids. We were finding where kids were struggling to find resources in their environment and then we acted as brokers or facilitators to try to find those. We're not just documenting what's going on and going "ha ha, they can't find these resources"; we're participating as well and we are trying to help move the system in a positive direction so that more youth have a chance to engage in STEM activities.

### *How difficult is it to measure interest in your work?*

It's difficult on a couple of different levels. It's difficult to orchestrate all these different measurement devices and also to find a way to integrate them together at the end to get a larger picture of what's happening in the community. I think we're still struggling to put it all together and assess on a large scale whether we are making a difference in this community. We can certainly see differences in individual kids or even in certain groups of kids, but the system as a whole is more difficult to measure. With Synergies, we're trying to figure out what the indicators are of a successful ecosystem approach to STEM interest development.

### *So you're measuring interest at the individual level, but now you're also grappling with what it looks like beyond the individual learner?*

Exactly. We are taking an ecosystem approach in this second phase of our research, working with different educational partners—not just schools and afterschool programs but parents, the business community, and other STEM-rich institutions like museums, zoos, and aquariums. We're even including media that are available to kids in digital or print. We're trying to better understand how all these different STEM entities work together, or don't work together, and how we can help them communicate and coordinate better so that kids can navigate the ecosystem. We want to help them create their own unique STEM learning and interest pathways across the day and throughout the year; we want to grease the wheels and make it easier for kids to find the things they're interested in and create these pathways.

### *When you were developing your instruments to measure interest, did you draw from existing instruments on interest?*

We did draw heavily from other instruments. The survey questionnaire is the ASPIRE questionnaire—that's Assets, Skills, Professions, Interests, Relationships, Environment. But we found that a lot of existing questionnaires focused on just one aspect or a couple of aspects of STEM, and we really wanted to break it down into the four dimensions—science, technology, engineering, and mathematics—so we did end up developing a major section of our survey. We still grabbed some questions from other surveys, but what we were really trying to do was allow the kids to show us through their answers to the questions how they conceptualized STEM. We started with 20 questions about what they're interested in. We didn't say, "Are you interested in science, are you interested in math?" We chose specific activities related to science, math, and technology that these youth would most likely have access to in their community, either in or outside school. For example, "How interested are you in taking things apart or putting things together?" We would conceptualize that as engineering, but that wording makes more sense to a kid than "Do you like engineering?" We also asked, "How much do you like to solve puzzles?" Rubik's Cubes are huge right now, so we have a question about Rubik's Cubes, and questions about video games and other consumer technology that youth would have access to and would know about. We asked all these questions to sneak up on them and find out how they're conceptualizing science, technology, and math without actually using those words, which can be confusing or off-putting. Especially math, you know; kids hear the word "math" and they're like, "blahhh…" But if you say puzzles or Rubik's Cubes: "oh, yeah, I like that." Then we used a factor analysis to help us find the underlying themes in all of these items, and it turned out the kids are conceptualizing all these things. At this point in their lives, they conceptualize science as Earth-based science, separate from life sciences, probably because that's how it's taught at school, so that's how they're starting to think about it. They conceptualize technology and engineering as one unit.

So that's how we got at their STEM interest in a way that was a little more learner-friendly and that gave us a level of detail that other studies haven't been able to achieve. Other studies were looking at different outcomes and they didn't need that finer level of understanding. We've been able to look at how these different dimensions of STEM interest change over time, not just on average for kids as a whole but with regard to gender differences, ethnicity, and other different groups. We can see what's going on in different dimensions of STEM over time, and we can also look at them all together as a single measure of just STEM interest. So I think that's the major way that our study has differed from other studies and at least for our purposes it's been a really useful way to help us understand how kids are conceptualizing interest and how that changes over time.

### *What are the tradeoffs of your approach to measuring and assessing?*

The tradeoffs are the same as in a lot of large-scale studies looking at an entire system. We can get a lot of data in a short time from our survey, but it's not a rich dataset and it leaves us with a lot of "why" questions. We can start to answer them with interviews and case studies, but that's far fewer youths, for a variety of reasons. We would love to have a cross-section of different youth at different interest levels, in different demographic categories, but of course you don't necessarily have a lot of control over who agrees to be in your case study or interviews. The same goes for the survey; we don't get 100% participation in that either. It's not an experiment, and we can't hold variables constant, so it's kind of a moving target and there's a lot of complexity and moving pieces. It makes it a little more difficult to understand what's going on, but over time, since it is a longitudinal study, I think we'll have enough data that we'll be able to make sense of things despite those challenges.

### *How and why do you think interest matters for science learning?*

Well, interest is a strong precursor to learning. People aren't going to learn about what they're not interested in. So I think it's very important. I think it's been understudied and undervalued in education for a long time. I think if teachers, both in or out of school, focused more on youth interests and had more activities that were targeted to youth interest, you might even see differences in some of the other outcomes that schools are interested in, like achievement and test scores. It's a motivational variable. Learners are really motivated—people of any age are very motivated—to learn about something in which they have an interest. I don't think it would change education or curricula a huge amount to have a little more focus on interest. You could just have a variety of activities. They could be learning the same concepts but in different ways that engage the different interests that kids have in the classroom with a learning environment.

### *The concept of interest is often associated with attitude, motivation, and identity. How do these connect with interest and how do you distinguish science interest from these other concepts?*

They're very connected, absolutely. It is hard to distinguish between them. I think attitudes are also affective and cognitive, but they're really an evaluation of a topic of activity: How do you feel about it? Attitudes don't necessarily correlate strongly with interest, because you can have a feeling or an opinion about something that you're not interested in. For example, you can say, "Oh, I think physics is a really important positive science for people to study, but I don't want to study it, I'm not interested in it." So interest and attitudes are associated, but they're not the same thing. That was an issue in early science education research when attitude was being conflated with interest, but they really aren't the same. Interest is really very motivational and it leads the interested party to want to reengage with the content, to learn more about it and become more knowledgeable, whereas attitude doesn't necessarily have that effect.

Motivation is very much enmeshed in our understanding of interest because interest itself is a motivational variable. If you're interested in something, you're motivated to learn more about it and find ways to reengage with it. But there's also the idea of what keeps you motivated as you're developing your interest, and what aspects are intrinsic versus extrinsic motivation. In early stages of interest, you need a lot of external support, which is extrinsic motivation, to keep you reengaging in the content and becoming more interested. But as you move into levels of individual interest, that's very self-generated. It's an intrinsic motivation, and you don't need someone telling you to go learn more about that or engage more in that activity. You are motivated just by your own personal goals to go out in the environment and find resources that help you sustain that interest.

As for identity, it's very much entwined in interest as well because as you move into the later phases of individual interest, you're also developing a strong identity as a person who does this sort of thing or knows a lot about this sort of thing. You're really developing a lot of knowledge about the topic or activity and a lot of value for it. It's something that adds to your life, that you feel you're good at, and other people come to you to learn more about it. So a lot of these measures are also measures in identity work and in the formation of one's identity as someone who knows how to do this. There's a lot of overlap in all of this work. The concepts support each other, and we should look at multiple constructs at the same time whenever we can to see how they affect each other.

### *What advice would you give to practitioners who are trying to integrate your findings about interest into their work?*

The advice I would give is attend to interest. Colloquially, we use the word "interest" as almost a throwaway word, without understanding the strong psychology and neuroscience behind it and how much it's a motivating factor in learning. But it doesn't take a lot of time for either classroom teachers or facilitators in other learning environments to do a quick poll of kids' interests and where they're at and try to revise or redo activities, create new activities, or revise old ones in a way that can take advantage of the existing interest of the youth. This can benefit teachers as well; it's much nicer to have a room full of interested kids who want to learn than a bunch of kids who are basically motivated by the test, if anything. The other thing I would say is that if you notice kids are getting interested in something in your class, you could do a poll at the end of your class to ask them what they really enjoyed learning about in that unit and what they would like to know more about. Then try to connect the kids to other resources so that they have that chance to reengage the interest and to develop an individual interest in something. For example, you could have someone come to the classroom and talk about opportunities that kids have in the community after that school unit is completed, or even just give them a list of websites or books they could read. Anything to help kids navigate the ecosystem. Kids are trying to create these interest pathways, maybe not consciously, but it's human nature to find ways to develop our interests. Anything that a teacher or facilitator can do to make that easier, whether it be information or other access issues, would be a net positive in our education system. It could make a big difference.

### *How do you view the concept of ecosystem in your work?*

Well, we're taking an ecosystem approach in Synergies in this next phase of our research. It's different for each learner, so the ecosystem should be centered on the learner, and the needs and interests of the learner should be supported by the STEM-rich opportunities that are available to them in the community and should be easily accessible. Our ecosystem is pretty local because it has to be easy for middle school kids to access. Of course, schools are important parts of the ecosystem, but they aren't the whole ecosystem, and they need help. That's not to slam schools in any way. Schools are doing the job that they are supposed to do. They're introducing the content and providing learners with an opportunity to learn a little bit about a lot of science and STEM topics. It's incumbent on the other members of the ecosystem to step in and provide the opportunities after the school has done their part. Those members include the afterschool programs as well as institutions in the community like science museums, nature centers, and so on. We haven't had a lot of success incorporating the business community yet, but we're going to be focusing on that because there are a lot of STEM businesses, like Intel, in our community. We want to find ways to incorporate them and have them feel like they're part of the ecosystem. The challenge is that unlike in an ecosystem in nature, in a STEM ecosystem many of the partners don't know they're in one. The challenge is convincing everyone who is in that community that they're an integral part of helping people learn about and become interested in STEM, and that they need to step up and do their part as an ecosystem member. For the business community, that could be mentorships, internships, or coming into the school and talking about the kinds of careers that are available, because a lot of kids don't know what STEM careers are available. Parents are so important too. That's something that's been coming out of our research for all eight years, the importance of parents in supporting their kids. By supporting, I mean actively supporting, not just saying, "Oh, you like astronomy, that's nice." Instead: "Oh, you like astronomy! Let's get this book out of the library. Let's go look at the stars together. Let's sign up for this astronomy club." And that's probably one of the strongest predictors of STEM persistence at that age group, for the kids we're watching. (It probably drops off as they get older.) Even if the parents can't support at that level, even if kids perceive that their parents have a positive attitude toward science and STEM, that's a strong predictor as well of STEM persistence. So really finding ways to engage parents in an authentic way in the STEM learning ecosystem would have huge payoffs in the future.

### *What are the big questions in informal science education, science communication, and even formal science communication for the next five or 10 years regarding interest?*

I think the big idea is this concept of an ecosystem approach, this realization that kids are only in school for X hours a day, and from what we know of how interest develops, there's a big need for reengagement and support, particularly at early stages of interest. So it's just not possible for the school to help kids develop these individual interests that are so important for persistence in STEM over time. We can't expect them to do that and then be disappointed that they don't. It's absolutely time for us to look outside of the school. The schools are a very important central part of the STEM ecosystem, but they have to be willing to work with other STEM providers in the community and vice versa. We need to think about STEM interest development as a pathway that kids are navigating and try to find ways to facilitate that. So I think there needs to be some sort of big event that gets people to think at a systems level. We're so siloed and all doing our own separate thing. But we have to work together and think about the learners in the ecosystem and what we can do to facilitate their learning and interest development across the day and throughout the year. Another thing we realized as we were working on this ecosystem project is that even though we now have a lot of afterschool programs, they were all during the school year, and there were essentially no opportunities available in the summer. These opportunities have to be distributed better across the year as well as across time. Kids need access to STEM-rich opportunities not just for a certain portion of the year but all year.

### *Is there anything else about interest in science learning that you wanted to share?*

I think the big "aha!" finding from the Synergies Project is just how important out-of-school factors are, not just parents but all out-of-school factors, in supporting interest development. We're finding this from our surveys and other data, and I know others have found this too. We're looking at a variety of factors and seeing how they affect STEM interest development longitudinally, so we're watching things happen over time. For the youth whose interest in a variety of STEM dimensions increased over time, the most important predictors were parents and participation in out-of-school activities, as well as some personal factors like relevance, knowledge about science or STEM, and enjoyment.

Enjoyment is another concept that people view as silly or superfluous in education. "Things don't have to be fun, they're supposed to be learning." But enjoyment came out as a strong predictor for all three years (6th, 7th, and 8th grade) of maintained and increased STEM interest, and for those who lost STEM interest, loss of enjoyment was a strong predictor. I think we can't discount these affective factors. When we interview kids who are in the STEM or the 4-H Science Club, one of the questions we ask is, "How does 4-H Science Club differ from your science in school?" And across the board the answer is, "It's fun. We do hands-on experiments. We get to talk to each other." I don't think that we should discount the importance of fun or think that you can't learn if you're having fun. And fun isn't too hard to achieve if it's just letting them talk to each other. I think the evidence is becoming stronger, and I hope that in the coming years we'll be able to provide more empirical evidence that fun is important in STEM learning and interest development. Maybe that's the key. Maybe it's not just okay to have fun in STEM classes but vital and critical. That's one of the take-home messages that we're getting from this project.

***Is there any particular level of participation in experiences outside of school that has been shown to maintain or increase interest?***

Unfortunately, we don't have dosage data, although we're hoping to have that in the second phase. We realized that would be an important predictor, but we didn't have a way to measure it. Frequency of participation is self-reported right now. There are five categories: every day, once a week, and so on. That's definitely something we're going to try to measure at a finer scale, maybe even getting the number of hours or at least the number of out-of-school activities that youths are engaging in. Some other studies have shown that dosage is the key; it's not even necessarily the quality of the programming, it's just how much they do, so I think it is an important thing to measure.

***Are there other instruments or measures that might get at that finer grain level?***

I don't know. I think that's something interest researchers are still struggling with. In individual case studies, where you're closely following an individual learner, you may be able to answer that, but on a large scale there isn't a good measure of those different levels of situational or individual interest. We did try a couple of things with our survey data to see if we could find those, and we found at least we're near the threshold where kids crossed over from situational to individual interest, but we couldn't identify the two finer scale levels within those phases of interest. That's a great area for researchers to look at in the future.

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