

Emergent Interests to Well-developed Interests in STEM

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Abstract: This study uncovers the intricate dynamics of interest development among three focal students from marginalized backgrounds as they engage in the Advancing Out-of-school Learning in Mathematics and Engineering (AOLME) program. It delves into how their *emergent interests* in STEM evolve (or does not take hold) into *well-developed interests*. We approach learning from the perspective that an individual's learning is intricately linked to the broader sociocultural environment they engage with and, in this context, interest plays a central role. The selected cases exhibited both similarities and differences in their paths before, during, and after the program, demonstrating how multiple facets contribute to the emergence and sustainability of interests. Observing how *discontinuities* and *continuities*, intertwined with affect and the cultivation of multiple identities, weave into one's *lines of practice*, provides insights into the interconnectedness that extends into subsequent activities, highlighting the role of learning in this ongoing process.

Introduction

Effectively engaging and nurturing students' interests not only leads to deeper and sustained learning but also promotes learning (e.g., Schiefele, 2009). Activities driven by personal interests guide participants toward highly individualized pursuits, leading to a diverse array of learning experiences (Azevedo, 2011). The particular characteristics of interests, both short-term and long-term, and the dynamics of participation based on interests give rise to significant considerations in the context of individual learning within activities (Azevedo, 2011, 2018; Barron, 2006). Acknowledging the diverse ways individuals engage in interest-based practices is essential for understanding the dynamics of learning within various forms of participation (Azevedo, 2011). While there has been an emphasis on enhancing the experiences of culturally and linguistically diverse students in STEM fields (NCTM, 2014), the limited focus on the experiences of minoritized students in the study of student interests underscores the urgent need for a more inclusive and comprehensive exploration of diverse perspectives. Hence, this study examines the development of interests for the three focal students from marginalized backgrounds as they engage in the AOLME program with an integrated Mathematics and Computer Science curriculum. This study aims to explore how their emergent interests evolve into well-developed interests. We begin by empirically assessing the following questions through the data: How and when does a student's emergent interest in STEM arise? How do these emerging interests mature into well-established ones, and what contributes to this process?

Literature review

To date, interest has been taken up as one way to consider student learning, motivation, and participation (Azevedo, 2018; Walker et al., 2004). On shorter timescales, researchers have examined *situational interest* (Azevedo, 2018; Renninger & Hidi, 2016; Schiefele, 2009), which “describes a short-term psychological state that involves focused attention, increased cognitive functioning, persistence, enjoyment or affective involvement, and curiosity” (Schiefele, 2009, p. 198). Existing concepts of situational interests often portray the phenomenon as a *discontinuity* in a person's experiences, framing it as a moment when a new object or activity enters their stream of experiences. Azevedo (2018) challenges this perspective, contending that focusing on *discontinuities* neglects the broader *continuities* that give meaning to one's overall experience. Anything deemed “interesting” in the form of a new and engaging activity emerges within the context of, and directly relates to, other activities in which an individual is concurrently involved. Comprehending activity *continuities* is crucial for understanding how new experiences, like emergent interests, become integrated into one's existing repertoire of activities.

Others explore and theorize the cultivation of an *individual (personal) interest*, referring to a long-term disposition to engage with a particular practice or set of activities (Azevedo, 2011; Renninger & Hidi, 2016). Instead of presuming that interest relationships primarily revolve around specific topics, Azevedo (2011) proposes that sustained engagement arises from the entirety of one's experiences in the practice. He presents a practice-centered theory of interest relationships - *lines of practice* - that is, “the pattern of long-term, self-motivated engagement in open-ended practices that has been theorized under the concept of individual interests” (p.147).

He illustrates how persistent engagement can be understood by examining the emergence, cessation, and alterations to an individual's lines of practice. Barron (2006) found that youth engaged in interest-based pursuits actively create learning opportunities within networks of people, practices, technologies, and values, known as learning ecologies, which are associated with different settings. Substantial literature exists on situational and individual interests, yet there is a scarcity of investigation regarding how these two are connected. There is a need for empirical examples that detail the dynamics of interest enactment and pursuit, spanning timescales of participation, contributing to our understanding of the processes of interest development.

Theoretical framework

We approach learning from a sociocultural standpoint, believing that these processes emerge and evolve through the interactions among individuals within their communities of practice (Lave & Wenger, 1991). Participation in practice is influenced by various structures and processes, such as norms, values, division of labor, tools, and artifacts (Lave & Wenger, 1991). These factors interact to shape how individuals participate, mediating and limiting various pursuits, and influencing the interests they cultivate over time (Azevedo, 2011, 2018). Therefore, a person's learning is intricately linked to the broader sociocultural environment with which they engage, and here, interest plays a central role (Greeno et al., 1996). An interest comprises various interacting dimensions of activity—material, social, cultural, psychological, physical, others—some of which align with past activities in one's life (*continuous*), while others diverge from them (*discontinuous*) (Azevedo, 2018). We draw on Azevedo's (2018) interest framework capable of capturing both continuities and discontinuities in a person's ongoing activity participation. Additionally, to comprehend persistence in a practice of interest, we utilize a theory of *lines of practice*, defined as “a distinctive, recurrent pattern of long-term engagement in a person's practice participation” (Azevedo, 2011, p.147). Any *line of practice* entails a set of closely interrelated activities defined by two structural elements: *preferences* and *conditions of practice*. According to Azevedo (2011), *preferences* refer to the deep, long-term goals, values, and beliefs that a person develops in the practice, whereas *conditions of practice* refer to the constraints and affordances impinging on the person's practice (e.g., socioeconomic status). A *line of practice* can be comprehended as the unique ways in which an individual's preferences adapt over an extended period to particular conditions within a practice, and how these preferences group together to form a line of practice. Building on his work (2011, 2018), this study asserts that identity development is inseparable from interest development, examining how it evolves in conjunction with the progression from emergent interest to well-developed interest and the pursuit of long-term interests. For instance, additional critical elements, such as the learner's *identity* processes and *affect*—the way a student feels—, are incorporated into the existing lines of practice. Affect can influence the decision-making aspect of preferences and identity development.

We use the term *emergent interest* instead of *situational interest* to better encapsulate and acknowledge the dynamic nature of interests. This choice is made to reflect that emergent interests are not confined to specific situations but can evolve and manifest over time, reflecting a more fluid aspect of engagement - emergent interests as a continuous and evolving process that can be influenced by various factors beyond immediate situations. Additionally, we use the term *well-developed interest* in lieu of *individual interest* or *personal interest*, recognizing that a well-developed interest is not strictly confined to individual or personal realms. Instead, it may be shaped by a complex interplay of multiple continuities and discontinuities, intricately woven into various backgrounds. By adopting these terminologies, the aim is to capture the nuanced and multifaceted nature of interests, emphasizing their dynamic connections to diverse social, cultural, and experiential contexts and contributing to a more comprehensive understanding of how interests develop.

Methodology

Study context and data collection

This research tracks the interest development of three students—Herminio, Julia, and Álvaro—during their participation in the AOLME program. The program was held at a bilingual middle school in a rural area in the Southwest region of the U.S. With Latinx students being the predominant student population, all students qualified for free or reduced lunch. The curriculum contains two levels. Level 1 introduced the basics of Linux and Python coding and included activities of image and video representations (the spring semester of each year from 2017 to 2019 in 1.5-hour weekly sessions for a total of 12 sessions). Level 2 focused on object-oriented programming and robotics (the summer of 2017 and 2018 in 3-hour daily sessions for a total of 12-15 sessions). During these sessions, students worked in teams (three to five peers) with co-facilitators (i.e., middle school students who participated in the program before) and an engineering undergraduate facilitator. Five data sources were used in the analysis: (1) video recordings of each session capturing participation of the students, co-facilitators, and facilitators, (2) video recordings of each group's computer monitor, (3) students' artifacts (i.e., binders, project

artifacts, digital files, journals), and (4) program evaluation sheets, attitude scales, and survey questionnaires, as well as (5) one-on-one and group interviews with students, co-facilitators, and facilitators. Notably, 6-7 years have passed since the students participated in the program. Herminio and Julia are currently pursuing engineering majors at a U.S. higher education institution, while Álvaro has joined the U.S. military. It is precisely these divergent trajectories that make them noteworthy and the reason they were chosen as focal students for this study.

Data analysis

We selected in-depth empirical cases illustrating the (re)emergence and development of three focal students' STEM-related interests. The selected cases exhibited both similarities and differences in their paths before, during, and after the program (i.e., having different feelings about a particular subject before the program, transitioning into different spaces after the program). The analytical procedures are in direct accordance with our theoretical framework. The process is not linear, and our portrayal of it is considerably simplified here. First, simultaneously with the open-coding of video recordings and all data sources following the time sequence (moving back and forth as needed) for each student individually (Miles et al., 2018), we generated logs encompassing personal, interpersonal, and community levels of activities (Rogoff, 1995). Throughout, we focused on whether students had genuinely developed an interest in STEM, examining how and when emergent interests arise, how these emerging interests mature into well-established ones, what are the relationships between continuities and discontinuities when an emergent interest does not take hold, and the contributing factors to these processes. We borrowed criteria from the literature (Azevedo, 2011, 2018) to categorize an instance as either a moment of emergent interest, or well-developed interest, or as part of the process in between. An emergent interest is identified by (i) a shift in a student's form of participation, reflected in (ii) increased attention, focus, and engagement, accompanied by (iii) increased production, such as artifacts or solutions to problems, and/or (iv) heightened discursive exchanges and interactions among participants in a scene. Then, if applicable, we examined the pattern of long-term, self-motivated engagement in open-ended practices, with a specific focus on *preferences* and *conditions of practice*. We sought to identify both *discontinuities* and *continuities* in one's ongoing activities, searching for moments of (re)triggering events. This analysis enabled the identification of distinct cases of emergent interest, characterized by a novel form of activity in the person's repertoire, as well as cases where interest developed into a well-established form, signifying a more long-term pursuit. To ensure that any candidate activity truly represented an emergent or already cultivating interest from an emic perspective, we revisited the data and also verified instances of interest observed in video recordings by cross-referencing with journal entries and interview data when feasible.

Results

The study uncovers the intricate dynamics of interest development among three focal students, demonstrating how multiple facets, including program design and learning ecologies, contribute to the emergence and sustainability of interests, influencing students' identities and future aspirations. Table 1 summarizes the progression of each student's interests toward well-developed ones, given the constraints of space.

Table 1
Students' Development of Interest in STEM Over Time

	Herminio	Julia	Álvaro
Before the program	He had an affinity and confidence in mathematics but no interest in computers or programming.	She felt "nervous" about mathematics due to a negative school experience. Programming was entirely new to her. She had an interest in games and pictures.	He enjoys math but occasionally struggles, describing himself as "not that smart." His personal hobbies include computer games and cars.
During the program as a student	He connected computer science and mathematics concepts, applying them to the real world, which influenced his overall interest in tasks.	Her interest in programming grew alongside her interest in mathematics. Her excitement grew through hands-on activities. Gaining a better understanding of the topics and their relationship boosted her confidence.	His interest was shaped by the process involving failures and successes. His learning ecology, including small groups, friends, family, hobbies, school, and future aspirations, sustained his interest in STEM.
Immediately after a year of participating in AOLME	He explicitly expressed his desire to pursue a career in STEM.	She felt at ease with mathematics and programming, seeing math as "fun" and programming as "easier." She wanted to serve as a co-facilitator for next year.	He felt more proficient in math and programming. He aspired to be a robot engineer. He wanted to be a co-facilitator and more involved in the program.

During the program as a co-facilitator	He gained confidence and recognized the significance of programming and mathematics in the real world. Developing his identity as both a programmer and a teacher, he desires for a career in programming.	Her sustained emergent interest is reflected in improved school performance. Cultivating an identity as both a programmer and teacher, she is eager to apply her learning in the real world and pursue a career in programming.	He developed a new identity as a robot engineer and as a teacher.
Now	He is pursuing a Bachelor's degree in Electrical and Computer Engineering at a U.S. higher education institution.	She enrolled in an undergraduate program in Electrical and Computer Engineering at a U.S. higher education institution.	He has joined the US Military.

Discussion

The emergence and timing of students' interests were influenced by factors such as novelty, affect, and the structural features of the task environment. Notably, the program's design played a crucial role in sustaining these emergent interests, fostering a supportive learning environment through team collaboration and co-teaching by co-facilitators and facilitators. We also discovered that new activities bear deep *continuities* with various aspects of one's life spaces. Students built confidence over time and established connections between emergent interests and the broader *continuities* that give meaning to one's experiences, demonstrating how their emergent interests connected with multiple *preferences* and *conditions of practice*. These continuities provide context and significance to emergent and novel forms of activity in an individual's practice, accounting for how discontinuities integrate into one's array of activities and empower students to pursue self-directed and self-motivated projects (Azevedo, 2018). For example, looking at how Judith's pre-existing affinity with pictures and games influenced the integration of her emerging interest in programming into her established set of activities and practices supports the assertion that emerging interests encompass both discontinuous and continuous aspects of experience (Azevedo, 2018) and further shows how such discontinuities and continuities weave into one's lines of practice. The students' learning ecologies (Barron, 2006), encompassing factors such as friends, family, hobbies, and school, were found to contribute to the emergence and fostering of interests. Moreover, their development of STEM interests was closely tied to applying their learning beyond the program, connecting it to real-world implications. As students progressed from emerging to well-developed interests, they underwent a transformative journey that encompassed diverse affects, acquiring multiple new identities such as programmers, robot engineers, and simultaneously as teachers, undergoing a shift in their perspectives. Observing how both discontinuities and continuities interlace within an individual's array of activities enables us to understand the interconnectedness that can extend into subsequent activities and illustrates the role of learning in this ongoing process.

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