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The *Synergies* Project: Preliminary Results and Insights from Two Years of Longitudinal Survey Research

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Subject/Problem

More than half a century ago it was observed that early adolescence was the time when youth began to lose interest in science (cf., Council for Scientific Policy, 1968). This trend continues to be true (Osborne et al., 2003) and evidence suggests that the problem may be becoming even more acute. In the last few decades several major cross-cultural studies have shown that interest in science, technology, engineering, and mathematics (STEM) peaks around 10 years of age and then falls (Catsambis, 1995; Martin et al., 2000; Sjøberg and Schreiner, 2005; PISA, 2007). This lack of interest has been implicated in the relatively low percentage of students earning degrees in STEM fields in the U.S. despite the warnings of severe projected shortfalls in the STEM workforce as baby-boomers retire (Lacey and Wright, 2009; Maltese and Tai, 2011).

Despite the widespread appreciation of this trend, understanding of STEM interest declines has been hampered by a number of methodological and theoretical issues within the research literature. First, most of the large studies that indicate significant declines in STEM interest during adolescence have relied on cross-sectional data rather than following a cohort of youth over a number of years. Such comparisons can be problematic if the populations are not readily comparable for some reason. Second, the concept of interest is complex; different researchers have approached interest from a variety of theoretical perspectives making it difficult to make meaningful comparisons among a range of interest studies (Krapp and Prenzel, 2011). Finally, the focus of virtually all previous work has tended to be on school science, ignoring any STEM activities in which youth may engage outside of school. Given this bias, it is not surprising that virtually all of the remediations that have been suggested have been school-based, e.g. improve number and quality of teachers, increase rigor of STEM courses (cf., National Research Council, 2006), despite the fact that interests emerge from an individual's experiences in all types of settings, not just during school hours (Falk and Dierking, 2010; Falk and Needham, 2013; Krapp, 2002; Zimmerman, 2012). Thus it is possible that youth may enjoy STEM topics and activities done for fun outside of school, while claiming to dislike science in the context of the classroom. We argue that a clearer understanding of what is happening to STEM

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interest both in and out of school during adolescence may allow more targeted interventions with a greater chance at successfully addressing declining STEM interests.

Our study seeks to improve understanding of how STEM interest develops during adolescence, and how a variety of community resources and out-of-school activities support that development. Our 4-year, *Synergies* project is a longitudinal study that documents STEM interest and participation trajectories of a cohort of middle school-aged youth as they progress from 5th through 8th grade. The premise of the project is that if one more fully understood how and why people, in particular early adolescent youth, develop STEM-related interests through the utilization of STEM resources, it should be possible to create a more effective STEM education system that more successfully supports STEM learning for all.

Methods

Our project focused on a single ethnically and socio-economically diverse neighborhood within Oregon. The target audience is served by a single school district and single representatives of the usual complement of informal education institutions/organizations (e.g., one science center, zoo, children's museum, public broadcasting organization, park district) as well as the usual kinds of after school community-based organizations (e.g., Boys and Girls Clubs, 4-H, afterschool programs and scouts). The community is large enough to mirror many of the complex dynamics of major urban areas, yet small enough to be manageable in both scope and scale.

In this longitudinal study, we are documenting STEM interest and participation trajectories of youth over 4 years (5th-8th grade) utilizing a mixed-methods research design comprised of questionnaires and in-depth interviews with a subset of case study families. Guided by the work of Hidi and Renninger (2006), Krapp (2002) and Azevedo (2011), we conceptualized interest as a multidimensional construct including affect (e.g. enjoyment), knowledge/competence, value (measured in terms of parental and peer support), and personal relevance. The questionnaire measured students' interests in STEM topics, their engagement in STEM activities, their use of STEM resources in their communities, and how their friends and families influenced their STEM interests and activities. Questionnaires were administered in 2011 when the cohort was in 5th grade, and 2012 when they were in 6th grade, and will continue to be administered yearly as these students progress through middle school to document changes in STEM interests and activities.

Analyses and Findings

In total, 175 youth completed the questionnaire as 5th graders, 142 participated as 6th graders, and 84 youth participated during both years. Comparisons for these youth revealed some significant patterns in STEM interests during this year (Table 1). In particular, interest in earth/space science topics (e.g. how stars and planets form), human biology (e.g. how the human body works), and technology/engineering (e.g. how buildings are made) increased significantly between 5th and 6th grade.

This was somewhat unexpected given the generally reported negative trend in STEM interests during adolescence. However, the youth were still in a fairly young developmental stage of science interest, so declines may yet become apparent in the coming years (Krapp and Prenzel, 2011).

In addition, a comparison of science interest factors revealed that self-reported interest in science did not change indicating that 6th grader youth still found science to be interesting (Table 2). However, despite the fact that 6th grader youth found science interesting, they also perceived it to be significantly more difficult than they did in 5th grade. In addition, 6th graders found science more relevant to their lives.

Table 1. Comparison of STEM interest indices between 5th and 6th grade-aged youth

	5th grade (n=83)		6th grade (n=83)			
Dependent variables[1]	**Mean**	**SE**	**Mean**	**SE**	**t-value**	***p*-value**
Earth/space science index	3.34	0.13	3.96	0.07	5.88	0.000
Human biology index	3.29	0.12	3.78	0.10	3.90	0.000
Technology/Engineering index	3.21	0.13	3.62	0.09	3.79	0.000

[1]Indices constructed of multiple items coded on a five-point scale from 1='dislike a lot' to 5='like a lot.'

Table 2. Comparison of science interest factors between 5th grade and 6th grade youth

	5th grade (n=78)		6th grade (n=78)			
Dependent variables[1]	**Mean**	**SE**	**Mean**	**SE**	**t-value**	***p*-value**
I find science to be really interesting	4.05	0.13	4.16	0.13	-0.78	0.439
I find science difficult	2.58	0.13	3.21	0.13	-4.03	0.000
I see how science relates to my life	3.29	0.12	3.71	0.14	-2.40	0.019

[1] Items were coded on a five-point scale from 1='Disagree a lot' to 5='Agree a lot.'

Table 3. Comparison of science interest factors and aspirations between 6th grade boys and girls

	Girl (n=71)		Boy (n=56)				Effect size
Dependent variables	**Mean**	**SE**	**Mean**	**SE**	**F-value**	***p*-value**	**Eta**
Positive science affect[1]	3.14	0.09	3.35	0.10	1.99	0.160	0.41
Science self-efficacy[1]	2.90	0.08	3.02	0.08	1.21	0.274	0.33
Science support[1]	2.70	0.09	2.75	0.09	0.10	0.751	0.35
Science relevancy[1]	3.17	0.08	3.29	0.09	0.97	0.327	0.24
Science aspiration[2]	1.58	0.10	2.07	0.11	10.49	0.002	0.38

[1] Index constructed of multiple items coded on a four-point scale from 1='Disagree a lot' to 4='Agree a lot.'
[2] Item stated 'I expect to become a scientist some day' and was coded on a four-point scale from 1='Disagree a lot' to 4='Agree a lot.'

Table 4. Multiple regression analysis of youth expectations of a career in science

Model[1]	Beta	t-value	*p*-value
Gender	-.223	-2.914	.004
My parents want me to be interested in science	.247	2.733	.007
I find science relevant to my life	.273	3.018	.003

[1] The model explains 28% of the variance in the expectation to become a scientist some day.

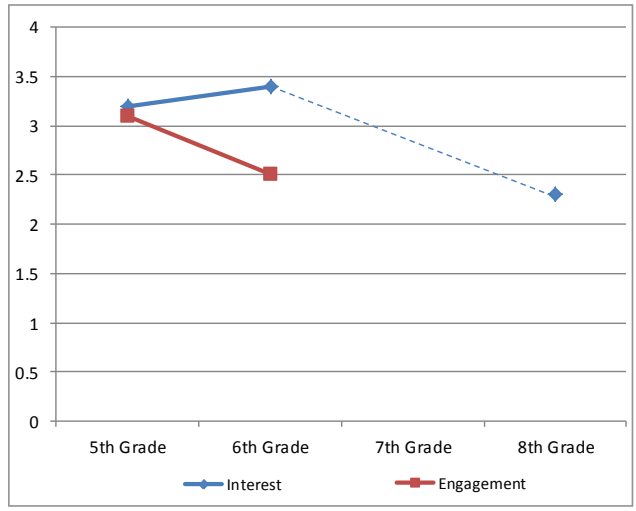
Despite many reports of girls' declining interests in science and math during adolescence (e.g. Haussler and Hoffman, 2002), we found no gender differences in our 4 science interest factors (Table 3). Sixth grade-aged youth reported high levels of science enjoyment and feelings of science relevance, but had lower levels of self-efficacy in science and perceptions of support from parents, peers, and teachers. Although boys had significantly greater science aspirations than girls, neither gender expected to become a scientist in the future. This is a particularly significant finding due to the importance of future science aspirations during adolescence in predicting later careers in science (Tai et al., 2006).

A multiple regression analysis of youth expectations of a career in science (Table 4) revealed that perceptions of the relevance of science in one's life and youth's perceptions of their parent's support for their interest in science were positive predictors of a future career in science, while gender, specifically being female, was a negative predictor.

Perhaps most significantly, the frequency with which out-of-school STEM-related activities and community resources (e.g. using the public library, watching a TV program about science, math or technology) that strongly correlated with reported interest in STEM showed significant declines between 5th and 6th grades. While the frequency of a few extra-curricular activities remained the same, there were no activities in which the frequency of participation increased between 5th and 6th grade and many of which declined. The changes in interest and activity participation is shown graphically in Figure 1, 8th grade data comes from transactional data collected from a separate sample of 8th grade youth from the same middle school.

Conclusions

Although findings are still preliminary (second year of a four-year study), they offer insights into how STEM interests develop over time and which activities and community resources may support the development and/or maintenance of these interests. Unlike cross-sectional studies, we are able to follow the interest and engagement trajectories of the same youth as they complete middle school. We can see how changes in STEM interest, science self-efficacy and other interest-related factors relate to both in-school and out-of-school experiences. In addition to revealing important patterns in STEM interest development. The patterns we are seeing suggest that although in the short-term, e.g., 5th to 6th grade, interest in STEM-related topics remains high, in fact increases,



Grade Level

Y-Axis based on 4 point Likert Scales, 1 = Low to 4 = High

Figure 1. Trends in youth interest and engagement by grade level

the underlying supports for these interests – engagement in STEM related activities out-of-school, parental encouragement and self-efficacy in STEM are beginning to crumble. Without these foundational supports, it appears likely that the STEM interest levels of our cohort of youth will, like the matched sample of 8th grade students from the same middle school, begin to precipitously decline beginning in 7th grade.

The detailed nature of our *Synergies* data is allowing us to identify where opportunities for science education improvement lie; key leverage points that would facilitate significant, strategic, cost-effective interventions. If we can understand what specific aspects of the STEM education infrastructure contribute optimally at different points across the day and lifetime – when, for whom and under what conditions – as well as how formal and informal institutions/organizations can work together in the service of STEM learning, we will be in a much stronger position to affect systemic STEM education reform.

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Synergies 計畫——一個長期追蹤調查研究的初步發現與啟示

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摘要

過去半個世紀以來，眾多研究顯示美國青少年在邁入青春期後，便逐漸失去對科學的興趣。但礙於研究文獻中的理論與研究方法的限制，影響這種興趣下降的關鍵因子一直沒有得到充分的探討。本報告嘗試透過一個 4 年的追蹤研究計畫，探討造成這種趨勢背後的原因。研究地點以美國奧勒岡州波特蘭市的一個校區為基礎，該校區擁有多樣的種族和社會經濟背景的學生，並具備自由選擇學習場域 (free-choice educational institutions) 如科學中心、動物園、兒童博物館，和其他課後社區團體如童子軍與課後輔導等。本研究採用混合研究設計，包括問卷調查和深度個案訪談，但本報告只呈現第一、二年問卷調查的研究發現。整個研究共有 175 位 5 年級學生完成問卷，6 年級學生則有 142 位完成問卷，而其中有 84 位學生參與了兩年跨年級的研究。初步分析顯示在 5 年級到 6 年級的過程中，在地球科學、生物學和技術與工程等科學興趣指標上均有顯著的提昇。而在影響科學興趣因子的學生自我評估方面，6 年級學生對「認為科學的確很有趣」和在 5 年級時沒有差別，但卻認為科學內容變難了，不過在「發現科學與生活有關連」這部分，6 年級學生也明顯比 5 年級學生有更高的知覺。此外，研究也顯示學生的性別在科學興趣因子上沒有顯著的差異。多變因迴歸分析顯示「學生對科學與生活有相關」與「學生對雙親是否認同科學興趣的感覺」，是學生未來是否從事科學工作的正向預測因子；但相反的，學生性別卻是負向的影響因子。作者最後指出，校外的科學學習對加強和維持學生的科學興趣，扮演十分重要的角色。

關鍵詞：科學興趣、科學教育、自由選擇學習
Keywords: science interests, science education, free-choice learning