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# INVESTIGATING FORTY YEARS OF STEM RESEARCH: HOW EXPLANATIONS FOR THE GENDER GAP HAVE EVOLVED OVER TIME

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*The gender gap in college-level STEM remains a persistent issue despite increased efforts to understand and address women's disparate participation. This scholarly article uses a meta-narrative systematic review of the literature to chronicle forty years of STEM-related literature, identify longitudinal patterns and themes in explanations of the gender gap in college STEM majors, and then evaluate the extent to which these explanations have evolved over time. Based on a systematic review of 324 full texts spanning the past 40 years of scholarly literature, five dominant meta-narrative explanations emerged: individual background characteristics; structural barriers in K–12 education; psychological factors, values, and preferences; family influences and expectations; and perceptions of STEM fields. The authors then used the resulting meta-narrative system to examine and document trends both across and within meta-narratives to draw conclusions regarding how scholars, practitioners, and policy makers have conceptualized the determinants of the STEM gender gap over time. Important implications for future research and practice are drawn based upon this analysis.*

**KEY WORDS:** *STEM, gender gap, meta-narrative systematic review*

## 1. THE PERSISTENT GENDER GAP IN COLLEGE-LEVEL STEM

In recent years, the U.S. federal government has identified the fields of science, technology, engineering, and mathematics (STEM) as "areas of national need," underscoring the notion that the nation's global status faces the potential of diminishing if more students do not enroll in and earn degrees in these fields (Goan and Cunningham, 2006, p. 1). Indeed, despite the inescapable reality of a technologically driven global economy, over the past decade the percentage of U.S. undergraduates pursuing bachelor's degrees in engineering, physical science, and math has remained stagnant, and the percentage of undergraduates pursuing degrees in computer science has actually declined (Drew, 2011; National Science Board, 2012).

In addition to stagnant or declining degree attainment in many STEM fields, another persistent issue is women's underrepresentation within STEM. Despite an emphasis in recent decades on creating equitable classroom experiences at the K–12 level, fostering pre-college women's math and science self-confidence, and recruiting young women into STEM, college women in the United States continue to enroll in STEM majors at lower rates than men, particularly in the fields of engineering and computer science (Jacobs, 1995, 1996; Sax, 2008). In fact, data from

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the National Center for Education Statistics show limited progress in the past twenty-five years, with women only marginally increasing their share of bachelor's degrees in engineering (from 14% to 17%) and markedly *declining* in their share of bachelor's degrees in computer science (from 36% to 18%) (U.S. Department of Education, 2012). Gender inequity in these areas of STEM degree attainment is particularly troubling in light of research stressing the importance of diverse classroom and work environments, which tend to foster creativity and an increase in problem solving skills (Blickenstaff, 2005; Carnevale et al., 2011; Lewis et al., 2000). Thus, by not diversifying STEM, the quality of scientific output may be compromised.

Women's underrepresentation in STEM is not a novel concern. Beginning in the early 1970s, a burgeoning body of research on the gender gap in STEM emerged and has continued to garner national and international attention (e.g., Cole and Cole, 1973; Davis et al., 1996; Epstein, 1970; Rosser, 2012). Concurrently, policy makers, educators, business leaders, and scholars alike have devoted heightened attention to enrollment and degree attainment of women in STEM fields. Despite the undeniable persistence and increasing urgency of addressing the STEM gender gap, relatively little progress has been made; women continue to be underrepresented in STEM fields in both higher education and the workforce (England and Li, 2006; Fox, 2001; Mullen, 2010; Spelke, 2005; Turner and Bowen, 1999).

## 2. CHANGING STUDENTS, CHANGING EXPLANATIONS?

Considering the importance of increasing enrollment in college STEM majors, particularly among women, a number of questions are brought to light. Perhaps most paramount is the simple query: Why do women enroll in STEM majors at lower rates than men? Despite the simplicity of this question and the wealth of research that has sought to answer it, the efforts of scholars, policy makers, and practitioners have remained relatively unsuccessful in closing the gender gap in STEM. A logical next question then becomes: Have we been studying the right things? That is, if we have yet to see significant shifts toward equitable representation of men and women within STEM fields, perhaps the literature has not accurately identified all key factors necessary to do so. Or, perhaps the reasons for women's underrepresentation have changed over time and the literature has not accurately identified new or evolving explanations for the gender gap in STEM.

In support of the latter possibility, research has documented tremendous fluctuations in the backgrounds, experiences, and aspirations of entering college freshmen (Pryor et al., 2007), including notable variation in these trends by gender (Sax, 2008). As such, we must question whether extant explanations for women's continued underrepresentation in STEM have also evolved over time, and to what degree this evolution, or non-evolution, has been suitably addressed in scholarship on the gender gap in STEM.

To address this overarching need, two related tasks are in order. First, it is useful to retrace the various ways in which the STEM literature has conceptualized the determinants of the gender gap. The work of Blickenstaff (2005) represents a notable starting point in the literature by chronicling and categorizing research-based explanations from 1970 to 1991. The author puts forth nine topical areas in which the STEM gender gap research has typically fallen: biological differences; academic preparation; attitudes toward STEM; a lack of role models; curriculum; pedagogy; "chily climate" in STEM classes; gender-role socialization; and epistemological differences. While useful, Blickenstaff's monograph is not inclusive of current literature, and does

not analyze potential evolutions in determinants. Thus, our second task entails using a widened temporal lens to draw inferences as to how the study of the determinants of women's participation in STEM has, or has not, shifted over time. This scholarly article uses a meta-narrative systematic review of the literature to chronicle and then evaluate the extent to which research regarding explanations of the gender gap in college STEM majors has evolved. The specific goal of this review is to answer the following conceptual questions:

1. What bodies of literature have been used to explain the gender gap in interest in STEM at the collegiate level?
2. To what extent have these explanations changed over time in terms of comparative prevalence?
3. How has research related to these explanations changed qualitatively (e.g., key constructs, methodological approaches, theoretical assumptions, and findings)?

This article is organized as follows: First, we introduce a conceptual model through which the choice of college major can be understood. Next, we outline our meta-narrative method for performing a systematic review of a variety of STEM literature produced over the last forty years. Following this, we present findings that highlight five major meta-narrative explanations for the STEM gender gap: individual background characteristics; structural barriers in K–12 education; psychological factors, values, and preferences; family influences and expectations; and perceptions of STEM fields. Here, we also determine if and how these explanations have evolved. Finally, through this examination, we draw conclusions regarding how the gender gap has been understood in the past, and offer implications for the course of future research dedicated to closing the gender gap in STEM.

## 3. CONCEPTUALIZING COLLEGE MAJOR CHOICE

The body of literature that considers how and why individuals make decisions about STEM career paths is vast, and women's representation has become a thoroughly researched topic within it. Extant research on the gender gap in STEM has sought to understand the factors linked to women's comparatively low participation and persistence in these fields by exploring academic and affective predictors spanning from as far as early childhood to the career level. As such, it is necessary to anchor our present review of the literature to a conceptual model of college major choice in order to allow for a systematic approach. To do this, we draw upon Lent, Brown, and Hackett's (Lent et al., 1994; 2000) Social Cognitive Career Theory (SCCT) as a means for making sense of the wide body of STEM literature as it relates to women's choice to pursue college STEM majors (see Fig. 1).

Social Cognitive Career Theory and its utility for explaining women's choice of a college STEM major is best understood as a proxy model taken from the career-development body of literature. The development of career aspirations and related goals is widely conceived of as a lifelong process (Ginzberg et al., 1951; Gottfredson, 1981; Super et al., 1990), and college major choice can be conceptualized as a benchmark achievement within this trajectory. Yet, no model exists that adequately predicts or explains individuals' decision to pursue a particular major and how this process may look different for men and women. For these reasons, Social Cognitive Career Theory is especially useful because it lends itself to our specific interest in (a) college major choice as a career-related decision, and (b) the role of gender in this process.

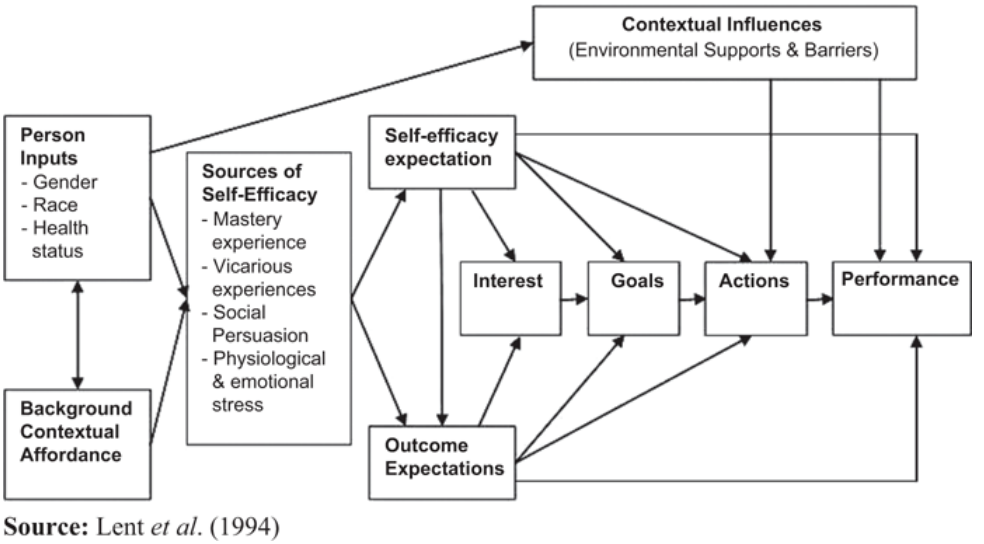


**FIG. 1:** Social Cognitive Career Theory (SCCT) Model (1994)

Derived from Bandura's (1977) Social Cognitive Theory, SCCT rests on three foundational "building blocks" of career development: self-efficacy, outcome expectations, and personal goals. Per SCCT, personal, contextual, and experiential factors influence individuals' perceived ability to successfully undertake the task (self-efficacy); their expectation regarding the personal value of pursuing the task, such as increased salary or employability (outcome expectations); and the determination to undertake the given task (personal goals). This model acknowledges the role of gender as a factor that influences the way individuals make career-based decisions, which for the purposes of our consideration of entering college students' academic trajectories, can be used as a proxy for STEM major choice.

As per SCCT, gender plays a role in career aspirations and related decisions as a construct that is socially defined. Lent et al. (2000) stress that such constructs act as frameworks for individuals' understanding of opportunity structures and their relationship to them within the societal context. As a result, it can be inferred that gender operates through self-efficacy and outcome expectations within the model. This aspect of SCCT is important because it allows for a contextualized understanding of major choice that explicitly acknowledges gender as a social construct. How, then, is SCCT applied as a framework for the systematic review of STEM literature to assess whether and how the determinants of college STEM major choice have evolved over time? In the following section, we discuss our methodological approach, drawing the appropriate linkages to SCCT as the guiding conceptual model where necessary.

## 4. AN APPROACH TO MAKING SENSE OF FORTY YEARS OF STEM LITERATURE

In order to gain a forty-year perspective on the ways that women's underrepresentation in college STEM majors has been conceptualized, we utilized Greenhalgh, Robert, Macfarlane, Bate,

Kyriakidou, and Peacock's (Greenhalgh et al., 2005) meta-narrative method of analysis. More specifically, we performed a systematic review of the literature and applied this meta-narrative method to our findings as "a way of systematically making sense of complex, heterogeneous and conflicting bodies of literature" related to the gender gap in college STEM majors (Greenhalgh et al., 2009, p. 732). In doing this, our analysis sought to compile and categorize all factors that hold significant weight within the available literature with respect to their use as researched determinants of women's participation in college STEM majors.

The meta-narrative method is founded on the technique of interpretive synthesis. Essentially this means that, in contrast to traditional meta-analysis methods that entail quantitative methods of synthesis, the narrative aspect of this method allows for a more fluid, subjective interpretation of the literature. Further, whereas meta-analysis calls for an assessment of how much "weight" should be given to the findings of a research study, the meta-narrative seeks to give voice to the over-arching storylines of one or many bodies of literature by summarizing key methods and findings (Gough, 2007). Greenhalgh et al. (2005) based the meta-narrative method on Kuhn's (1962) notion of scientific paradigms as a means to achieve this purpose. By conceptualizing extant literature in terms of paradigms, it is possible to map various discourses of research as they have unfolded across multiple research traditions, and by different groups of scholars, over time.

There are three key characteristics of the meta -narrative. First, it "embraces a shared set of concepts, theories, and preferred methods, including an explicit or implied set of quality criteria against which 'good research' is judged" (Greenhalgh et al., 2009, p. 732). These shared properties might be discerned through multiple techniques including, but not limited to, set inclusion criteria, search methods, and comparative analysis. Second, the meta-narrative includes a time dimension. By looking back, researchers are able to utilize this method of analysis to synthesize past research traditions to inform future avenues of research. In the present analysis, we elected to consider the past forty years due to the notable emergence of STEM literature in the early 1970s. Finally, the meta-narrative is meant to exemplify where in the literature scholars may be disagreeing, rather than to highlight the extent of agreement among researchers (Greenhalgh et al., 2009). This is a particularly important point, as our present interest in the evolving nature of research related to women's underrepresentation in college STEM majors does not explicitly necessitate "disagreeing" per se; in this way, the final meta-narrative characteristic must be left open for interpretation as to what constitutes a disagreement in the literature. For our purposes, it is not essential that the emerging research blatantly refutes past findings, but rather, explores or focuses on different aspects as it develops.

To achieve these methodological characteristics, we operationalized our present meta-narrative analysis as follows. First, we selected initial inclusion criteria which all literature in the review must fulfill. Next, a two-stage literature search was conducted to locate potential sources for the systematic review. Following this, we performed a screen of literature yielded from the search. Finally, using the interpretive synthesis technique, we categorized and analyzed the literature via an iterative process of taxonomy development. Figure 2 presents a model of this process with information regarding the number of works yielded in each step. Each of these steps is described in greater detail below.

### 4.1 Criteria for Eligibility in the Review

The sheer volume and expanse of gender-related STEM research, paired with the aforementioned tenets of the meta-narrative methodology, begs purposeful parameter setting. Accordingly, in-

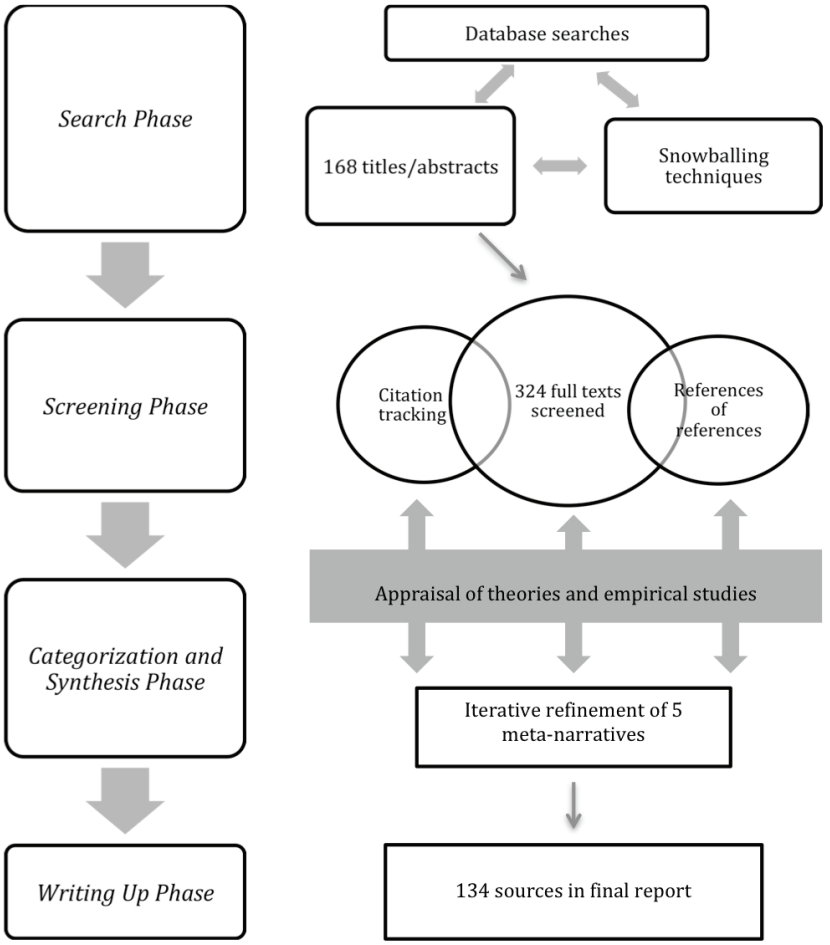


**FIG. 2:** Summary of meta-narrative systematic literature review

clusion criteria were set on three main dimensions: gender component, population, and STEM-related outcomes. Further, only studies published in English and after 1970 were included in the review. With respect to the first criteria dimension, studies and reports included for systematic review must contain an explicit link to gender and/or biological sex.

The second criterion related to population and included two considerations drawn from SCCT. First, a salient aspect of SCCT relates to cultural and socialization processes that may function uniquely depending on context. Because of this, we elected to constrain our review to empirical research that took place within the United States. Further, non-empirically based references were included only if they addressed the STEM climate within the U.S. Second, because SCCT is based on the premise that one's career-based decisions are the culmination of a complex history of life events and experiences, we included literature spanning various developmental stages up to the college years.

Finally, in order to fully assess the multitude of STEM gender gap determinants, the criterion of "STEM-related outcomes" was purposefully left broad. As per SCCT, cognitive and affective factors play a role in goal development and career aspirations. Thus, outcomes related to STEM included in this review span from high school course-taking decisions to specific academic outcomes such as a student's grade point average.

### 4.2 Literature Search

The literature search took place in two phases. To begin, we used exploratory methods to locate pertinent literature via electronic databases from a variety of fields, including education, sociology, psychology, public policy, and economics. Additionally, "gray literature," such as working paper series and other national reports, were included in the search. In a second phase, we used a snowballing approach to identify additional research and related literature. This technique, which includes hand-searching bibliographies of previously located articles, is the most efficient means to locate meta-narrative resources (Greenhalgh and Peacock, 2005). Accordingly, the two-stage search yielded a range of literature that included national reports, books, descriptive studies and surveys, programmatic studies, and causal studies that were relevant to the scope of the review, published between 1970 and the present, and representative of qualitative, quantitative, and mixed-methods studies. Collectively, the abstracts of 168 sources were compiled during this phase.

### 4.3 Literature Screening

In order to ensure quality within the literature yielded from our search, a screening process was adopted from Greenhalgh and colleagues' (2009) systematic literature review. Among the 168 sources compiled, those that met the selection criteria based on abstract review were included for full-text screens. Then, by way of citation tracking and reverse searches using references of references, additional sources were included in the full-text screening phase. In total, 324 full texts were screened during this phase. In order to ensure both quality and diversity of research considered for meta-narrative analysis, the screening process was designed to be inclusive of a wide range of approaches and research paradigms. For these reasons, we opted not to use a formal scoring system by which we assigned weight to studies, reports, and articles included in the review. Rather, in line with meta-narrative methodology, we identified seminal sources within the STEM literature, and made note of the concepts, theories, and preferred methods to form baseline criteria for the appraisal of additional literature sources.

### 4.4 Categorization and Synthesis

Following the screening phase, the bulk of the meta-narrative method focused on the categorization of materials deemed appropriate for inclusion in the review. Here, appropriateness is defined as having passed the full-text screening phase by meeting each of the selection criteria; 134 sources were included in the final categorization and synthesis phase. Because the meta-narrative method is highly iterative, this process does not follow an explicit set of rules, and is based instead on the general guidelines needed in order to "map, interpret and critique the range of concepts, theories, methods and empirical findings" (Greenhalgh et al., 2009, p. 730). Given the expansive nature of the literature related to women's decisions to pursue a college

STEM major, initial classification schemes were developed to best capture emergent streams of literature that appeared to share commonalities with SCCT. Selected works were then tested for fit within the classification schemes, and subsequent adaptations were made via the addition of new themes, combination of multiple themes, and/or elimination of themes. Thus, this was a constructivist process and required ongoing dialogue to eventually achieve agreement in both our own taxonomy as well as the application of where literature sources were categorized within the scheme. This allowed for themes within each meta-narrative to organically take shape from the literature. Foundations for the formation of these schemes were based on, but not limited to, key constructs, methodological approaches, theoretical assumptions, and findings (see Table 1 for final coding scheme).

## 5. MAIN FINDINGS: META-NARRATIVE EXPLANATIONS FOR THE GENDER GAP IN COLLEGE STEM MAJORS

Upon review of the literature, five topical areas emerged as salient meta-narrative approaches to understanding the gender gap in college STEM majors: individual background characteristics; structural barriers in K–12 education; psychological factors, values, and preferences; family influences and expectations; and perceptions of STEM fields. Notably, research within each meta-narrative is inevitably interrelated with that of others, and are characterized by overlapping sources of impact. Accordingly, while the complexity of these interrelations renders the practice of categorization imperfect, the use of the SCCT model and related grouping techniques provides an important baseline analysis of the gender gap in STEM undergraduate majors.

Returning to the original research questions, the following discussion provides two lenses through which we make sense of the literature. First, we analyze major characteristics of the literature vis-à-vis the comparative prevalence of these five meta-narratives over the past forty years in order to identify broad, overarching themes across the literature. Second, we take a more focused approach by examining the nature and evolution of research *within* each meta-narrative.

### 5.1 Literature Trends in the Aggregate

At the broad level of analysis, distinctive trends are evident regarding the overall dissemination of STEM gender gap research over time, as well as the comparative prevalence of the five meta-narratives during this period. Upon examination of STEM-related literature, the earliest published studies regarding women were introduced in the early 1970s (e.g., Epstein, 1970; Stein and Bailey, 1973; Tangri, 1972); however, this research represents only the beginnings of such work, as the bulk of research related to women's underrepresentation within STEM fields emerged in the 1980s and has grown exponentially since (see Fig. 3).

If we conceptualize this expanse of literature within the five meta-narratives (individual background characteristics; family influences and expectations; structural barriers in K–12 education; psychological factors, values, and preferences; and perceptions of STEM fields), a number of patterns emerge. First, an analysis of research published during this time span reveals moderate but notable thematic shifts in the explanations of the underlying causes of the STEM gender gap at the undergraduate level. Specifically, the literature prior to 1980 tended to focus on structural barriers in K–12 (e.g., Fennema and Sherman, 1978), psychological factors, values, and preferences (e.g., Stein and Bailey, 1973), and family influences and expectations (e.g., Lipman-Blumen, 1972).

**TABLE 1:** Systematic review coding scheme

| Review aspect | Classifications | Description/examples |
|---|---|---|
| Source type | 1. Empirical | a. Peer-reviewed journal article<br>b. Dissertation research<br>c. Special volume/book |
| | 2. Non-empirical | a. Peer-reviewed journal article<br>b. White paper<br>c. Gray paper |
| Methodology | 1. Quantitative | a. Descriptive<br>b. Regression-based<br>c. SEM/HLM<br>d. Quasi-experimental design<br>e. Experimental |
| | 2. Qualitative | a. Interview<br>b. Focus group<br>c. Ethnographic/participation action research |
| Unit of analysis | 1. Individual | |
| | 2. Institution | |
| | 3. System | |
| Sample | 1. Nationally representative (y/n) | Sample is reflective of national population of chosen unit of analysis |
| | 2. Subsample | Sample is representative of a specified subsample of individuals/institution(s)/region(s) |
| Ontology | 1. Positivist | A single reality. Knowable, probabilistic. |
| | 2. Interpretivist/ Constructivist | Multiple realities, socially constructed through symbolic interactionism, framing, and sense making |
| | 3. Critical | Multiple socially constructed realities reflecting power relations hence influenced by external forces |
| Theoretical assumptions and values | 1. Deficit vs anti-deficit | Deficit: Research orientation focuses on the failure or shortcomings of women in STEM; emphasis on understanding reasons for women's underrepresentation.<br>Anti-deficit: Research orientation focuses on enablers of success for women in STEM. |
| | 2. Structural barriers vs individual barriers | Structural barriers: Attributions of women's underrepresentation in STEM are focused on systems that deter women from participating in STEM.<br>Individual barriers: Attributions of women's underrepresentation in STEM are focused on individual-level differences that predict participation in STEM. |
| STEM-related outcome | 1. Affective/non-cognitive | Latent constructs related to affect or personality (e.g., math self-concept). |
| | 2. Academic/cognitive | Discrete measures of achievement/ability (e.g., grades, IQ). |

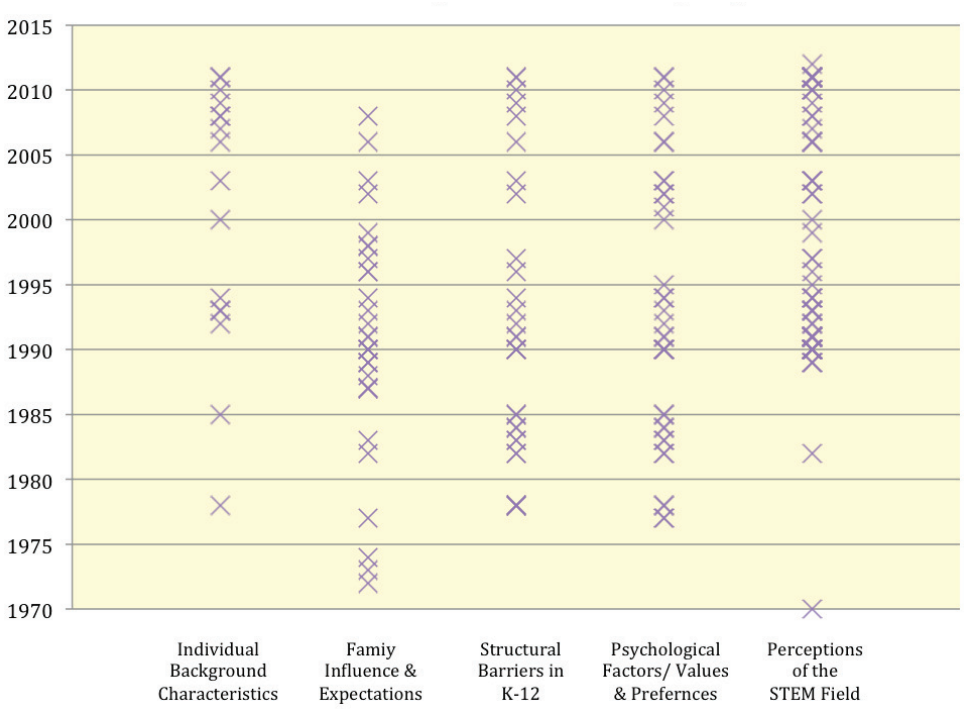


**FIG. 3:** Dates of gender gap in STEM publications, 1970 to present

In contrast, and discussed below, later research witnessed an increasing focus on students' backgrounds and their perceptions of STEM fields. Further, although research on structural barriers and psychological factors has persisted to the present day, studies examining the influence of family on the STEM gender gap have become less prevalent since the early 2000s.

While research on most of the areas mentioned above either persisted or declined, two areas of study have received increased attention since their rise in the 1980s: individual background characteristics and women's perceptions of the STEM fields. Indeed, research with a focus on race and socioeconomic status (SES) as primary variables of interest began to emerge and expand throughout the late 1980s and early 1990s. Further, a punctuated shift occurred in 1990, when scholars began to focus their work on attempts to identify and understand the ways that women may view their prospects in STEM at the college, graduate, and career levels (e.g., Sax, 1994; Seymour and Hewitt, 1994).

### 5.2 Changes in the Nature of Explanations

Elaborating upon the preceding holistic, broad-stroke analysis across meta-narratives, we now turn to the more intricate nuances witnessed within each of these five topical areas. Although the ways and degree to which some of these areas have been researched and understood as determinants of the gender gap in STEM have evolved, others have experienced little change. The following discussion presents new insight to the type of scholarship that has been produced

to explain the gender gap in college-level STEM fields within each of the following five meta-narratives: individual background characteristics; structural barriers in K–12 education; psychological factors, values, and preferences; family influences and expectations; and perceptions of STEM fields

### *5.2.1 Meta-narrative 1: Individual Background Characteristics*

As previously noted, the incidence of literature relating to individual background characteristics as determinants of college STEM major choice increased considerably in the late 1980s and early 1990s, and has continued to today. Due to its burgeoning representation as compared to the other four meta-narratives, an examination of subtle evolutions in this body of literature required great care. Despite this, we make two primary assertions with regard to how literature that considers individual background characteristics as determinants of women's interest in college STEM majors has changed over the past decades.

First, a noticeable shift occurred with respect to the convergence of race and socioeconomic status (SES) as a construct of interest in the research. Earlier work dedicated to understanding women's underrepresentation in STEM tended to regard race and SES as related, but separate, input variables (e.g., Kahle, 1982). Further, in these earlier studies, SES was the more dominant and seemingly preferred variable utilized to understand variability across and within groups of boys and girls. However, a more intersectional approach emerged in the 1990s that highlighted the importance of considering the interplay between race and SES as predictors of STEM participation. Madigan (1997) used national data to examine relationships between science course taking and proficiency, notably controlling for a construct titled "race-ethnicity" which combined the two variables to form a more nuanced input variable, in addition to an SES construct. This trend follows in line with various research agendas (e.g., gender studies) that have made the conceptual shift toward regarding race and SES as inextricably related constructs (Crenshaw, 1991).

We also found that the literature evolved from broader-based studies in which background characteristics such as race and SES functioned as input variables to those that are guided and delimited by these constructs. Specifically, whereas STEM gender gap research in the 1970s and 1980s relied more commonly on representative samples in which race and SES are held constant, more recent work, especially within the past decade, has sought to disaggregate samples in order to understand race- and/or class-based nuances in the predictors of women's STEM participation. For example, case-study approaches such as Fadigan and Hammrich's (2004) examination of the impact of an informal science education program on the career trajectories of girls from "urban, low-income, single-parent families" (p. 2) have become increasingly more prevalent in the literature.

Additionally, a wealth of research (e.g., Espinosa, 2009; Hurtado et al., 2011; Perna et al., 2009) has begun to narrow in on the unique experiences of underrepresented minority students in STEM fields at the baccalaureate level. A particularly important contribution to this initiative lies in Ong, Wright, Espinosa, and Orfield's (Ong et al., 2012) review of forty years of research related to women of color's experiences in baccalaureate- and graduate-level STEM fields; this work incorporates attention to the temporal component, similar to our present work, and also sought to identify important shifts in the literature.

### *5.2.2 Meta-narrative 2: K-12 Structural Barriers*

Despite the abundance of research regarding structural barriers in compulsory educational, this meta-narrative has experienced relatively minor shifts in the ways researchers study determinants of the gender gap in STEM. Over time, these barriers have been persistently described in terms

of schools, teachers, pedagogy, curriculum and preparation, achievement, classroom structure as determinant of peer interaction, and standardized tests. As an illustration of structural barriers, we might consider research pertaining to course-taking behaviors. Studies have consistently explored high school females' interest in taking high school math and science courses (Czujko and Bernstein, 1988; Huang and Brainard, 2001; Kinzie, 2007; Meece et al., 1982) and how interest might be diminished by classroom experiences. Though the subjects, contexts, and methods have inevitably changed over time, the key construct typically remained the same. Interestingly, despite the apparent lack of evolution in terms of the topical interests within this body of literature, this area of research also represented the most growth in sheer volume of research and publication. That is, within each of the aforementioned topics, a great wealth of research emerged to better understand the ways in which these recurring topics of structural barriers predict women's lower participation in STEM. A notable trend that has persisted throughout this burgeoning meta-narrative is the prevalence of quantitative, longitudinal studies from large national databases (e.g., National Assessment of Educational Progress, National Center for Education Statistics).

While there are a number of intricate nuances that have shifted within this line of research, such as methodologies, populations of reference, and historical context, studies of structural barriers in K–12 education as a determinant of the STEM gender gap can still be broadly understood within the same basic categories mentioned above. Thus, significant thematic shifts were not readily apparent in the study of structural barriers in K–12 education as a determinant of the gender gap in STEM.

Still though, we might revisit our analysis of literature trends in the aggregate to make further commentary on the K–12 structural barriers meta-narrative. A primary observation is that K–12 schools represent a significant institution of study within the research related to higher education outcomes such as the choice of a STEM major. In addition, we witness a fundamental debate—nature versus nurture—play out within this body of literature, and possibly impact subsequent lines of inquiry in other meta-narratives. That is, in the 1970s and 1980s, a stream of education research focused on the question of *biologically based* inclination towards STEM fields (Benbow and Stanley, 1983; Gray, 1981; Maccoby and Jacklin, 1974). Concurrent and later research within this meta-narrative, as well as family influences and expectations and perceptions of the field meta-narratives, began to explore *socialization* issues to explain women's comparatively low interest in these fields. This cross meta-narrative dynamic underscores the interrelatedness of the various bodies of literature that seek to address the same issue.

### *5.2.3 Meta-narrative 3: Psychological factors, values, and preferences*

The study of this meta-narrative presented the greatest challenge among the five explanatory areas of the literature. Whereas other meta-narrative traditions focused on a comparatively greater number of discrete and tangible research constructs, the analysis of a body of literature that primarily addresses highly latent concepts was a formidable task. Regardless, topical evolutions within the literature are evident and worth noting.

This body of literature tended to focus on self-confidence and/or self-concept within academic disciplines, personality orientation, and sense of belonging in STEM. Each of these subcategories represents a varied approach to making sense of the psychological aspects of women's STEM-related decisions. Further, each focus area has enjoyed variable levels of prominence over the years with a great deal of interplay in the literature; this suggests that these explanations for the STEM gender gap play overlapping and complementary roles. If we begin by looking at the topic of self-confidence and/or self-concept in academia, it is readily evident that this is by far the

most oft-cited explanation for the STEM gender gap. Beginning in the 1970s and 1980s, a great deal of the literature began to explore gender differences in elementary school children's beliefs regarding aptitude in math and science, revealing stronger self-perceived abilities among males than females (e.g., Campbell and Geller, 1984; Eccles and Jacobs, 1986; Entwisle and Hayduk, 1988; Fennema and Sherman, 1978). Interest in self-confidence and self-concept has extended into the current decade, and now explicitly links these factors to the choice of college major (e.g., Sax, 1994, 2008; Sax and Bryant , 2006) and examines college women's performance versus confidence (e.g., Zhao et al., 2005).

The focus on personality orientation represents a second subcategorization within this meta-narrative and has enjoyed shifting avenues of research over time. While much of the early literature in this tradition took a deficit approach by framing the STEM disciplines as competitive fields that demand a competitive personality, which is viewed as less dominant among women than men (Belenky et al., 1986; Gilligan and Gilligan, 1982; Noddings, 1984), later work used a different conceptual approach. Specifically, this area of research framed the debate in an anti-deficit discourse, positing that women are more service-oriented (Baker and Leary, 1995; Sax, 1994, 2001), hold epistemological orientations that are more intuitive, synthetic, and holistic (Keller, 1985), and more interested in life sciences due to these fields' clearly understood connection to improving the human condition (Baker and Leary, 1995; Sax, 2001; Thompson and Windschitl, 2002).

The third and final subcategory of the psychological meta-narrative exists in the literature on sense of belonging. This is the newest area and has garnered increasing interest since the 1990s. Literature published within this vein revolved around topics such as the gendered notions of certain STEM fields (Cheryan et al., 2011; Margolis et al., 2000; Nosek et al., 2002) and what Brush (1990) termed as "double-marginalization" of women who feel ostracized within what is stereotyped as "male" and "nerdy" fields. Much of this work might be considered as derivatives of Hall and Sandler's (1982) seminal work, which introduced the notion of the "chilly climate" for women in STEM classrooms.

Thus, two trends have occurred. First, our analysis suggests a movement away from the notion that women do not pursue STEM majors and careers simply due to a lack of interest in these fields. Instead, the literature has increasingly pointed toward contextual influences that are perceived to shape women's aspirations. This point resonates with our use of SCCT to conceptualize college STEM major choice, in that it takes into account the important role of environmental and social context in shaping individuals' aspirations. Second, and relatedly, the unit of analysis within these types of explanations has shifted from the individual to classroom-based, institutional, and occupational contexts. This movement demonstrates a more complex, and interrelated perspective on the types of psychological factors, values, and preferences that play a role in women's decisions to pursue a STEM major in college.

#### *5.2.4 Meta-narrative 4: Family Influences and Expectations*

Literature related to the impact of families on women's interest in pursuing a college STEM major spans nearly the entire past forty years (1974 to present). Although this body of literature represents a diverse set of approaches to understanding this dynamic, it is perhaps best understood as divided between two primary camps: literature that focuses on gender-role socialization and that which considers self-concept (the latter representing an intersection with the psychological meta-narrative). As discussed below, research has tended away from explicit connections to familial gender-role socialization and shifted toward the education-psychological construct of self-concept.

Early literature on gender-role socialization tended to focus on the ways in which daily, lived conditions within family life translate to explicit and implicit expectations for children in the academic domain. As an example, Chodorow (1974) asserted that young girls are not taught processes of individuation and separation in the same way that young boys are within the home, and are therefore more likely to adopt multiple facets of their mothers' identities; this potentially included the mother's traditional role in the home as opposed to within the workforce. Daughters of mothers who were employed during their childhood/adolescence showed higher career aspirations than those whose mothers stayed at home (Tangri, 1972; Huston-Stein and Higgins-Trenk, 1978). As a result, this literature nodded toward a recursive process in which women had difficulty breaking through gendered roles. Some have even asserted that gender-role differences are established before formal compulsory schooling (i.e., kindergarten) through socialization processes at home (Baker and Jones, 1993; Levin and Barry, 1997). There was also a tradition within the earlier literature to study more discrete manifestations of this subversive gender-role socialization such as the provision of types of tools (Mullis and Jenkins, 1988), mechanical games and computers (Eccles, 1992), and toys (Eccles and Jacobs, 1986).

Over time, however, we note a conceptual shift in the literature from these discrete and measurable variables within the home to an increased focus on relational factors and behavior. For example, a number of sources began to examine relationships between daughters and their mothers and/or fathers (Tenenbaum and Leaper, 2003; Vetter, 1996). In the 1990s, a growing number of scholars began studying parent occupation as an influential aspect of parent-child relationships (Astin and Sax, 1996; Sax, 1994; Vetter, 1996). These studies differed from earlier work in this vein that tended to measure the impact of the rank and/or associated prestige of the parent's work, but not the actual occupation (e.g., engineer father). In this way, a distinction is drawn in the literature between explicit behaviors that occur on a daily basis and implicit relational impacts that result from children's perceptions of their parents.

The aforementioned shift to less discrete variables, such as relational factors and behavior, represented the main overlapping period during which gender-role socialization began to give way to self-concept and other related latent constructs. Certainly, self-concept was studied in great depth prior to this time (e.g., Lipman-Blumen, 1972; Stein and Bailey, 1973), but a marked increase occurred in the 1990s. For example, Seymour and Hewitt (1994) found that women felt less pressure from parents to complete a STEM major and that self-concept within these fields was related to this dynamic. Others have focused explicitly on the ways that parents' beliefs about their children's ability in math or science are directly related to children's self-concept in these areas (Gunderson et al., 2012; Leedy et al., 2003; Tenenbaum and Leaper, 2003).

Thus, it seems that although subtle shifts have occurred in the ways that family influences and expectations have been conceptualized as explanations for the STEM gender gap, the general trajectory of this research has remained on course with issues of socialization and self-concept. Perhaps the most evident shift across both of these camps is an increased emphasis on the ways that parents influence children's aspirations. Specifically, the study of discrete variables such as toys has declined over time, giving way to more work surrounding parent relationships and behaviors.

#### *5.2.5 Meta-narrative 5: Perceptions of STEM*

Women's perceptions of STEM as a meta-narrative yielded a comparatively clearer evolution when compared to the other four meta-narratives. This particular topical area takes a broad perspective on how women perceive their prospects for academic, professional, and affective outcomes in STEM fields (e.g., Tolbert and Moen, 1998). Included in this body of literature was

work that considered three STEM environments: college, graduate school, and the workplace.

Earlier studies tended to focus on women's understandings of potential constraints in objective terms, such as hours spent working away from family or financial aid dollars, as predictors of their lowered participation in STEM (Thorne, 1993; Mohrman, 1987). More recent work has trended away from these more discrete conceptualizations of women's concerns about careers in STEM, and has become more concerned with subjective indicators of potential for women's success in these fields. Scholars have become increasingly interested in STEM contexts that transmit unwelcoming or unappealing messages to women who may be considering STEM as a potential career (e.g., Xie and Shauman, 2003). For example, studies began to look at interpersonal interactions, cultural norms, and personal satisfaction in this type of work as predictors of women's participation in STEM (Blickenstaff, 2005; Carnevale et al., 2011). This shift in conceptual and methodological design was evident in work related to all three environments (undergraduate, graduate, and career), potentially signaling a movement toward a more tightly aligned understanding of women's goals and needs from the baccalaureate level through career decisions.

## 6. LIMITATIONS

Given the large expanse of literature that exists to explain the gender gap in STEM paired with the unique methods we utilized, the present study is limited in certain respects. First, the various bodies of STEM research that address the gender gap are incredibly robust. Because of this, we limited our analysis to literature from the past forty years in order to place constraints on the quantity of research considered. However, it would be remiss to assert that this meta-narrative analysis could be carried out in such a way that all relevant literature was systematically reviewed and categorized. Rather, as noted in our methods, we sought to explore meta-narratives that emerged from the literature until these topical areas reached a level of saturation deemed sufficient by the researchers.

Further, as was expected per the meta-narrative method, the categorization and analyses undertaken in the present study were undeniably messy and signature of an intensely iterative process. Research related to the gender gap in STEM is rich and diverse both conceptually and methodologically. As such, a number of studies did not fall neatly into one topical area, and often shaped multiple meta-narratives simultaneously. Dialogue and constant comparative analysis were implemented to make purposeful choices regarding whether and how to adapt various sources of literature across meta-narratives; however, this type of analysis is admittedly subjective and without analytic tools that allow for an "exact science." Further, and relatedly, it should be noted that the use of SCCT as a guiding model for analyzing explanations of the gender gap in STEM major aspirations was a useful approach to making sense of a large body of literature, but does not represent the sole strategy for conducting a meta-narrative analysis on the topic.

Finally, it is also important to note here that a finer-grained analysis, as was used to explore the changing nature of explanations *within* each of the five meta-narratives, presents notable challenges within the meta-narrative method (Greenhalgh et al., 2005). In particular, the interpretive synthesis that was implemented during this phase of our analysis was implicitly less accurate due to the fact that each meta-narrative topic area was limited to a somewhat homogeneous body of literature; certainly, uncovering subtle trends via this narrow scope is a challenging task. Thus, within our evaluation of each meta-narrative, what is gained analytically in terms of subtlety and nuance is done so at the potential cost of reliability.

## 7. CONCLUSION AND IMPLICATIONS FOR FUTURE RESEARCH

The gender gap in STEM remains a persistent problem in American education and the workforce despite decades of research documenting explanations for this phenomenon. As Drew (2011) notes, "Women…are consistently discouraged from studying science and mathematics, the very subjects that would give them access to power, influence, and wealth" (p. 195). Though it is generally understood that the nature and extent of the gender gap varies over time and by field, it is unknown whether explanations for the gap have *changed*. This article focuses on the extant literature to address whether and how the scholarship on the STEM gender gap has evolved over the past four decades.

As described in this article, research examining the gender gap in STEM generally describes the gap in enrollment within five meta-narratives, and has done so in a relatively consistent manner. These meta-narratives are: individual background characteristics; structural barriers in K–12 education; psychological factors, values, and preferences; family influences and expectations; and perceptions of STEM fields. At the aggregate level, we found interesting patterns with regard to the comparative prevalence of these meta-narratives over time. Two topical areas have enjoyed relatively consistent attention within the literature: structural barriers in K–12 and psychological factors, values, and preferences. In contrast, one topical area, family influences and expectations, was found to decline in prevalence after the early 2000s. Finally, an additional two topical areas emerged with greater prevalence later in the literature (early 1990s): individual background characteristics and perceptions of the field. Thus, the extent to which each of these meta-narratives is investigated varies with time, suggesting shifting approaches for how we make sense of women's participation in STEM, and academia in general.

Further, it appears that, to varying degrees, the way researchers have investigated each of these five meta-narratives has changed over time. While certain meta-narratives, such as student background characteristics and family influences and expectations, seem to have experienced notable changes both conceptually and methodologically, the approach to studying other meta-narratives, such as K–12 structural barriers, has not evolved in any major way. Of additional interest here is that the lines separating each meta-narrative have become increasingly blurred. For example, findings related to the impact of school type on girls' intent to major in STEM could be categorized under structural factors, or could be considered as individual background characteristics given that SES often dictates the types of schools available to students. Indeed, while the general existence of these five meta-narratives supports Social Cognitive Career Theory, this model of career-related behavior stresses the *interrelated* dynamics of these sources of influence. Thus, shifts in prevalence among the five meta-narratives may characterize important changes in the ways scholars and researchers are making sense of the inextricably interrelated nature of determinants of the gender gap in undergraduate STEM fields.

There are key research implications to be derived from this evolving understanding of the gender gap in STEM. First, it is important to examine the extent to which programs and policies aimed at recruiting more women into STEM are actually informed by findings from extant research, and further, whether they are attentive to the evolving nature of this literature. The American Association of Colleges and Universities' (AACU) Project Kaleidoscope (PKAL) is an exemplar of this type of systematic initiative that incorporates a reflective lens in its objectives (AACU, 2012). By engaging various stakeholders, PKAL has identified the task of

examining shifts in its twenty years of past research to better inform future strategies. This type of exercise is both necessary and important given the relative degrees of evolution that occur in different areas of STEM gender gap research. This implication lends itself to action research at both the university and programmatic level. Researchers should be encouraged to create partnerships with outreach programs in order to better investigate how outreach programs are utilizing current research, while simultaneously increasing their ability to gather research on women in STEM. These efforts then can be utilized by the programs themselves to better serve their student populations.

Second, to the extent that there exist multiple and evolving meta-narratives for understanding the gender gap in STEM, researchers studying this issue ought not focus on a single explanation for the gender imbalance. The fact that some explanations may have fallen out of favor over time (e.g., family influences) does not suggest that the reasons for the gender gap have actually changed. In fact, future research should address this issue head on by considering if and how the meta-narratives such as family influence, background characteristics, structural barriers, etc., operate simultaneously in predicting women's STEM enrollment, and should test if this functions differently today than in the past. In doing so, researchers also ought to be sensitive to the above-mentioned blurring of lines between meta-narrative explanations and acknowledge the extent to which predictors of the STEM gender gap may span multiple categories.

Third, a clear implication of the present work relates to the need for focused research at the subfield level. Although the gender gap in STEM varies significantly by subfield; most research has examined STEM in the aggregate. The lack of subfield research does further disservice to the topic of the gender gap by presuming that the explanations for women's underenrollment in computer science (for example) are the same as those for engineering or physics. In fact, only a few studies have examined the gender gap in subfields of STEM, and most of these have focused on computer science and engineering, where the largest gender gaps persist (see Lent et al., 2005; Lips and Temple, 1990; Tillberg and Cohoon, 2005). Expansion of the present study into subfield-specific research presents a large area of growth for STEM scholarship. Specifically, researchers need to begin to delve into the explanations for why women have made inroads in fields such as biology, but remain underrepresented in fields such as computer science and engineering. These investigations would need to consider how the nature of work and the culture of different STEM fields serves to encourage or discourage enrollment among women. Further, such research would ideally consider the multiple STEM meta-narratives identified in this study as explanations for the gender gap.

Finally, in considering the implications brought to light by this meta-analysis, we are struck by the breadth of research available on the topic of the gender gap in STEM, relative to the modest progress that has been made in women's STEM participation. By endeavoring to understand the extent to which explanations for the gender gap in STEM have evolved, we move closer to understanding the persistent nature of this phenomenon. Knowing how these explanations have or have not evolved in the literature will inform current researchers as they seek to further understand this topic. However, as noted, such inquiry should attend to variations across STEM subfields and should investigate the extent to which program and policy is actually informed by evolving explanations for women's persistent underrepresentation in STEM. Ultimately, recruitment of a diverse population of women and men into individual STEM majors in college, and eventually the workforce, is dependent upon understanding why individuals are motivated to pursue different STEM fields.

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