Research Report

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RESEARCH REPORT

Crosscutting Literature on STEAM Ecosystems, Expectancy Value Theory, and Social Emotional Learning: A Metadata Synthesis

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In this report, we describe the initial stages of a crosscutting research effort to characterize literature reviewed across 8 different projects—each with objectives aligned toward improving student engagement in science, technology, engineering, arts, and mathematics (STEAM) fields. These projects sought to identify malleable factors (e.g., motivation, persistence) that could potentially be fostered to improve achievement motivation and build participation among historically underrepresented learners in STEAM pathways. Focusing on both the extent to which different broad and facet-level constructs are both discussed and assessed in a diverse pool of literature, we developed a standardized reporting structure and catalogued detailed information on 236 unique references. We found that, as a proportion of the number of times constructs in the STEAM, expectancy value (EV) theory, and social emotional learning (SEL) spaces were discussed in the reviewed literature, they were assessed relatively infrequently. We also found high levels of overlap in the literature across the above 3 focal areas, highlighting both the need to document new assessments designed to support STEAM engagement and an opportunity to use them to evaluate expectancy value theory as a holistic model.

Keywords Metadata; literature review; STEAM; social emotional learning; expectancy value theory

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In recent decades, increasing attention has been focused on identifying the barriers limiting and factors supporting underrepresented students' participation in science, technology, engineering, arts, and mathematics (STEAM) educational pathways and careers. In 2011, a National Research Council report entitled *Expanding Underrepresented Minority Participation: America's Science at the Crossroads* noted that although science- and engineering-related careers will continue to be critical to sustaining economic prosperity in the United States for the foreseeable future, students identifying as belonging to racial and ethnic minority groups remain vastly underrepresented in these fields (National Research Council, 2011). Problems of equity, access, and the retention of minority students in STEAM educational programs and fields have implications for the strength of the U.S. economy. According to a number of governmental agencies (e.g., American Association for the Advancement of Science, 2001; National Academy of Sciences, National Academy of Engineering, & Institute of Medicine, 2007), the productivity and strength of the U.S. economy is expected to significantly decline without the representative participation of minority groups in undergraduate and graduate STEM (science, technology, engineering, and mathematics) degree programs.

The STEAM Ecosystems Project

Educational Testing Service (ETS) has recently sharpened its focus on research related to underrepresentation in STEAM education. In the current report, we describe efforts in the STEAM Ecosystems project—a research initiative focused on methods of increasing participation and engagement in STEAM education. The long-term, overarching goal of the project was to identify opportunities to strengthen educational STEAM pathways for underrepresented groups (e.g., African Americans, Hispanic or Latino Americans, women) through research on how key motivational, social, emotional, and inter- and intrapersonal factors affect the development of important STEAM competencies and practices. STEAM Ecosystems research at ETS included a diverse set of formative STEAM activities (e.g., learning games and simulations, conversation-based assessments, hands-on activities and portfolio development, writing-to-learn tasks, interactive digital

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dashboards). These activities were designed to provide both learners and educators with formative feedback across multiple educational factors (e.g., competencies, practices, personal and social variables), grain sizes (e.g., individual, team, and task), and time points (e.g., during and after an activity, summarizing multiple activities).

Although the larger STEAM Ecosystems initiative is aimed at improving related outcomes for underrepresented minority students, its initial stage of research was broadly exploratory in nature and involved multiple subprojects conducting literature reviews aimed at identifying malleable factors (e.g., motivation, persistence) that could potentially be fostered through newly developed activities and modifications to existing task designs. All such activities and tasks were designed to improve achievement motivation through increased student autonomy, engagement, collaboration, and perceived task value, with the project's ultimate goal being to deploy them in efforts to build participation among historically underrepresented learners in STEAM pathways.

Crosscutting Ecosystem Themes

A crosscutting strand of work within the STEAM Ecosystems project documented literature reviewed by staff conducting multiple subprojects. These reviews focused on how different STEAM domains and learning environments incorporated theory on achievement motivation as well as assessments of social, emotional, inter- and intrapersonal factors related to engagement with STEAM, and the development of key competencies and practices. The objective of this crosscutting work was to provide a comprehensive view of how factors related to STEAM engagement and achievement were represented across the current set of Ecosystems subprojects. The resulting documentation was intended to illustrate the depth and breadth of (as well as gaps in) the coverage of the above types of factors in the literature being used by STEAM Ecosystems subprojects.

There were two objectives for documenting crosscutting themes. The first was to conduct a comprehensive evaluation of expectancy value (EV) theory applied to multiple STEAM task environments. Applied to education, EV theory posits that students' academic motivations and behaviors are functions of both (a) beliefs about the extent of their own abilities (i.e., expectancies), and (b) several aspects of the perceived importance (i.e., value) of a given task or objective (Wigfield, Tonks, & Klauda, 2009; see Table 1 for descriptions of major components of EV theory). We utilized the EV perspective on achievement motivation because of its long-standing focus on student beliefs and values regarding achievement. Much of this work has targeted students' beliefs about and values concerning mathematics and science, and how they relate to participation and engagement in these domains. A large body of this research has been conducted with middle and high school student populations and with traditionally underrepresented groups, such as female students (Wigfield et al., 2015). By documenting the use of EV theory in the literature reviewed across STEAM Ecosystems subprojects, we aimed to identify how specific motivational components (i.e., expectancies of future success, intrinsic value) were relevant to differently structured task environments (e.g., digital dashboards, portfolios, conversation-based platforms), bearing in mind that the particular requirements of each environment may elicit unique patterns of student engagement.

The second objective was to document coverage of social emotional learning (SEL) themes across subprojects. SEL skills and attitudes such as resilience, emotional intelligence, and self-efficacy are important to STEAM engagement and success. These types of constructs are also directly relevant to EV theory from a conceptual perspective and have shown promise as practical behavioral targets, given their susceptibility to change as a result of school-based interventions (e.g., Durlak, Weissberg, Dymnicki, Taylor, & Schellinger, 2011; Durlak, Weissberg, & Pachan, 2010). Recent reports have contributed to the widespread acceptance of the value of "noncognitive" or SEL skills to public education (Farrington et al., 2012; Kautz, Heckman, Diris, ter Weel, & Borghans, 2014; Kyllonen, Lipnevich, Burrus, & Roberts, 2014; National Research Council, 2012). These researchers have also considered vital practical issues such as the extent to which noncognitive skills are malleable, and mechanisms to achieve their reliable and valid assessment.

The malleability of SEL skills across the early and adolescent lifespan (Carneiro, Crawford, & Goodman, 2007; Cunha & Heckman, 2010; Cunha, Heckman, & Schennach, 2010; Roberts, Walton, & Viechtbauer, 2006) is crucial in motivating educators and researchers alike to prioritize efforts to measure and encourage positive trends in student development. More recent research has demonstrated similar findings related to students' motivation to learn in STEAM fields (e.g., Lin-Siegler, Ahn, Chen, Fang, & Luna-Lucero, 2016; Park, Gunderson, Tsukayama, Levine, & Beilock, 2016). Given evidence that high-fidelity interventions to encourage student motivation and growth in other noncognitive skills may

Table 1 Fields and Operational Definitions Used to Document Literature Across STEAM Ecosystems Subprojects

Category	Field or construct	Categories reported or operational definition
Description of reference	Full publication reference	For citation
	Publication year	4-digit year (e.g., 2002)
	Resource type	Journal article Book or chapter Technical report (e.g., ETS research report/memorandum) Presentation Conference proceedings
	Population (If more than one group, select group w/largest *N*)	Early childhood (pre – K) Elementary school (K – 5) Middle school (6 – 8) High school (9 – 12) Higher education (2 – 4 yr.) Adult learning (e.g., training)
	Sample size	< 50 50 – 99 100 – 499 500 – 1,000 > 1,000
	Type of study	Theoretical or lit review Cognitive lab or think-aloud protocol Qualitative Observational/correlational Experiment/RCT Meta-analysis
STEAM domain addressed	Science	Yes or no
	Technology	Yes or no
	Engineering	Yes or no
	Arts and/or design	Yes or no
	Mathematics	Yes or no
	STEAM general	Yes or no
Expectancy value theory	Expectancy of success	Individual's beliefs about how well they will do on upcoming tasks, either in the immediate or longer term future
(Coding whether each construct was discussed only vs. empirically assessed; same convention used for mindsets and SEL below)	Utility value	How well a task relates to current and future (e.g., career) goals A task may be positively valued because it is useful for future goals, though the individual may not be interested in the task for its own sake. For instance, students may take a class that they do not intrinsically enjoy but is useful for pursuing other interests, such as pleasing their parents, getting into college. The utility value component captures extrinsic reasons for engaging in a task (see Deci & Ryan, 1985, Harter, 1981) and an individual's short- and long-term goals.
	Attainment value	The personal importance of doing well on a task, or relevance of engaging in a task for confirming or disconfirming salient aspects of one's self-schema A task may allow an individual to demonstrate aspects of the individual's actual or ideal self-schema, such as competence in various domains. A task will have higher attainment value insofar as it allows the individual to confirm their self-schemata.

Table 1 continued

Category	Field or construct	Categories reported or operational definition
	Intrinsic value	The enjoyment of performing the activity or the subjective interest the individual has in the subject The intrinsic value component is similar to the definition of Harter (1981) and Deci and Ryan (1985) of intrinsic motivation. It is also similar to interest and flow as defined by Csikszentmihalyi (1988), Renninger, Hidi, and Krapp (1992), and Schiefele (1999).
	Cost	Cost characterizes the negative aspects of engaging in the task. Cost may include performance anxiety, fear of failure, the effort needed to perform well, as well as the lost opportunities that result from engaging in one task rather than another.
	Student goals	Achievement goals are the broad purposes children have for learning or doing different activities.
	Self-schema/self-concept	One's internal framing or conceptualization of one's own abilities
	Affective reactions/memories	Affective memories associated with having performed tasks similar to the present one in the past
Mindsets and social emotional learning (SEL) (discussed vs. assessed)	Entity vs. incremental	For example, fixed versus growth mindset. Beliefs that intelligence and ability are fixed and unchangeable correspond to the entity theory of intelligence (fixed mindset). Beliefs that one can accumulate intelligence through hard work and effort correspond to the incremental theory of intelligence (growth mindset).
	Theory of intelligence	One's underlying (implicit) beliefs about whether or not intelligence or abilities can change
	(Achievement) motivation	Need for success or the attainment of excellence (typically academic excellence, in the educational literature). Individuals are driven to succeed by both internal and external influences.
	Engagement	Refers to the degree of attention, curiosity, interest, optimism, and passion that students show when they are being taught or learning. This extends to the level of drive they have to learn and progress in their education.
	Self-efficacy	Extent or strength of one's belief in one's own ability to complete tasks and reach goals
	Grit/perseverance/ persistence	Tendency to sustain interest in and effort toward long-term goals
	Self-regulation/ self-control	Ability to control one's emotions and behavior in the face of temptations and impulses
	Communication/ social skills	*Communication*: Act of conveying intended meanings from one person or group to another through a variety of means (e.g., written, oral, visual) *Social/interpersonal skills*: Any skill facilitating interaction with others. Social rules and relations are created, communicated, and changed in verbal and nonverbal ways.
	Coping	To invest conscious effort to solve personal or interpersonal problems, in order to try to master, minimize, or tolerate stress and conflict. Coping strategies can be either positive (e.g., problem focused) or negative (e.g., avoidance).
	Stress/anxiety	*Stress*: a state of mental or emotional strain or tension resulting from adverse or challenging circumstances *Anxiety*: a feeling of worry, nervousness, or unease, typically about an imminent event or something with an uncertain outcome

Table 1 continued

Category	Field or construct	Categories reported or operational definition
	Teamwork/ collaboration	Ability to cooperate with others, influence others through support and encouragement, resolve conflicts or disagreements among group members, and guide or mentor other group members
	Problem solving	Process of finding solutions to difficult or complex issues
	Action planning	Ability to break down a complex task into smaller elements to achieve a specific goal. Action planning may also involve clarifying what resources are required, formulating a timeline for when specific tasks need to be completed, and the like.
	Integrity	Quality of being honest and ethical in one's work and interactions with others

Note. Definitions of utility value, attainment value, intrinsic value, and costs were adapted from language in Wigfield, Battle, Keller, and Eccles (2002).

lead to improved STEAM engagement, educators taking steps to inspire holistic student development (vs. remaining focused on purely academic subject matter) in districts serving those from underrepresented or historically disadvantaged backgrounds may see their efforts translated into narrowed achievement gaps between these students and their more socioeconomically advantaged peers.

The attention to achievement motivation and SEL is *not* to suggest that a sudden focus on fostering student motivational and noncognitive skills will independently solve long-standing structural and societal problems inherent to underresourced school systems. However, it seems reasonable to surmise that students enrolled in such systems might benefit from STEAM-related interventions (such as those encompassed within the STEAM Ecosystems framework) designed to heighten their abilities to cope with, navigate, and persist through academic (and potentially other types of) challenges they may encounter.

Whether directly or indirectly, the research cited above targets motivational constructs central to EV theory. As is always the case in empirical research, each study also relied on *assessments* of such constructs to generate its data and findings. The crosscutting STEAM Ecosystems work does the same, but moves the field a step forward in its explicit connection of SEL (and assessments of its facets) to EV theory's five primary elements (expectancy of success plus four value components, described below). One fruitful consequence of the crosscutting work reported here will be the eventual mapping and adaptation of available instrumentation to the theoretical constructs prioritized in EV theory. This will permit the efficient integration of a newly configured suite of EV assessments with (and within) the STEAM learning environments being developed in both other strands of the Ecosystems project and other STEAM-related research in general.

Method

During 2017, eight of the 15 subprojects contained within the larger STEAM Ecosystems project reviewed relevant literature in their focal area(s). Five of these reviews were focused on aspects of conversation-based assessment. Two were specific to studies concerning digital dashboard platforms, and one concentrated on hands-on and portfolio-based tasks and observations. In each case, staff working on each subproject developed procedures for surveying the literature and summarizing it to serve their purposes. It is important to note that the phrase "literature review" is used in a broad sense throughout this report because the scope of work it implied varied across subprojects. Some subproject reviews were limited in scope such that only a few articles were required for review to inform specific decisions relevant to achieving the subproject's deliverables (e.g., designing an experiment or feedback mechanism). Such limited reviews would typically not have resulted in narrative reports of their findings. Subprojects at earlier stages of their work on a particular topic tended to involve a more comprehensive review of the literature designed to build the team's general base of knowledge, as opposed to informing decisions concerning a particular deliverable.

Our primary objective in this study was to describe salient characteristics (i.e., metadata) of the large body of literature reviewed across eight STEAM Ecosystem subprojects, both to determine common elements across different existing

Table 2 Publication Type

	# of unique references	% of unique	# of coded constructs	% of coded
Book or chapter	28	12%	105	9%
Conference proceedings	25	11%	104	8%
Dissertation/thesis	4	2%	14	1%
Journal article	154	65%	920	74%
Presentation	6	3%	29	2%
Technical report	19	8%	63	5%
Total	236	100	1,235	100

strands of work and inform future efforts by highlighting knowledge gaps (i.e., motivating future studies). This required the development of a structure for cataloguing the details of such literature review work, operationalized as a spreadsheet analogous to the type used to document material reviewed in service of a formal meta-analysis (Card, 2012). The fields and information collected using this spreadsheet are detailed in Table 1. All subproject team members responsible for literature review work were trained on how to use the spreadsheet (i.e., how and when to enter data into each field), with each reviewed document incorporated into the spreadsheet by the same team members.

Although Table 1 provides specific detail and operational definitions for each of the document characteristics and constructs of interest to this study, in general four types of information were catalogued. First were general descriptors of the studies or articles reviewed (e.g., publication year, study type, sample size). Second, we documented the particular STEAM domains addressed by the document. Third, literature was coded for either discussing or empirically assessing constructs associated with EV theory (Wigfield & Eccles, 2000). Fourth, the construct space was expanded beyond EV theory to include a broad range of noncognitive or SEL constructs (e.g., perseverance/grit, teamwork, communication skills, self-regulation) important to supporting student success (Farrington et al., 2012; Kautz et al., 2014; National Research Council, 2012). This space also included student mindsets, coding discussion, or assessment of constructs related to students' beliefs about whether their ability to succeed academically was fixed versus malleable (Dweck, 2008; Dweck & Leggett, 1988).

Once all articles had been coded across the eight subprojects, we reviewed all entries for duplicates to detect cases in which the same article had been coded across multiple subprojects. Six such articles were found, which were reconciled to a single entry in a combined spreadsheet containing all references catalogued across subprojects. Any coding discrepancies between subprojects were resolved through review of the original source document and discussion within the research team. Data on each coded document characteristic in the combined spreadsheet were then aggregated over all reviewed literature and summarized in tables (presented in detail below).

Results

We present descriptive results organized by the five types of information described above and in Table 1. Practically all literature coded for this study mentioned multiple constructs of interest. As a result (and unless otherwise noted as reflecting a count of unique references), all figures reported here reflect counts of a given characteristic over the entire sample of coded constructs. Overall, 236 unique references were catalogued in this project, resulting in 1,235 coded attributes in our database (M attributes per reference = 5.23, SD = 4.45). Six (2.5%) of the 236 references were catalogued by multiple subprojects, indicating little overlap in the literature reviewed for their different purposes.

Table 3 Publication Year

	# of unique references	% of unique	# of coded constructs	% of coded
Before 2000	17	7%	57	5%
2000–2009	68	29%	258	21%
2010–2017	151	64%	920	74%
Total	236	100	1,235	100

Table 4 Study Type

	# of unique references	% of unique	# of coded constructs	% of coded
Cognitive lab, other protocol	10	4%	42	3%
Experiment/RCT	44	19%	192	16%
Observational/correlational	64	27%	507	41%
Qualitative	23	10%	129	10%
Theoretical or lit. review	95	40%	365	30%
Total	236	100	1,235	100

Table 5 Target Population

	# of unique references	% of unique	# of coded constructs	% of coded
[Not specified]	18	8%	62	5%
Early childhood (Pre–K)	1	0%	6	0%
Elementary school (K–5)	22	9%	81	7%
Middle school (6–8)	29	12%	193	16%
High school (9–12)	41	17%	344	28%
Higher education (2–4 yr.)	75	32%	363	29%
Adult learning or training	11	5%	47	4%
Multiple populations	39	17%	139	11%
Total	236	100	1,235	100

Description of Reference

In this category, we report figures for both unique references and the total number of coded instances of each characteristic. This provides a descriptive picture of both the broad sample of references reviewed in this project and the extent to which different reference subgroups contributed to the extraction of detailed construct-level information. Several tables display results by publication type (Table 2), publication year (Table 3), study type (Table 4), target population (Table 5), and sample size (Table 6). References reviewed were predominantly journal articles (65%), followed by books or book chapters (12%) and conference proceedings (11%). Journal articles also accounted for nearly three quarters (74%) of coded constructs. The bulk of references reviewed (64%) were published recently (since 2010), with an additional 30% published between 2000 and 2009.

In terms of study design (Table 4), the types of reports reviewed varied from qualitative research (10%) to randomized controlled trials (19%), with 40% classified as theoretical or consisting primarily of a literature review. An additional 27% of studies were observational or correlational in nature. Although correlational studies made up the second largest subgroup in terms of unique articles, they accounted for a plurality (41%) of coded constructs across subprojects. Reviewing Table 5, one quarter (57) of the 236 references reviewed either addressed multiple student age groups (17%) or did not specify a target population (8%). Among this subgroup, the vast majority (88%) were broad-ranging theoretical papers or literature reviews. An additional 32% of all references were focused on higher education, with 17%, 12%, and 9% targeting high

Table 6 Sample Size

	# of unique references	% of unique	# of coded constructs	% of coded
[Not specified][a]	83	35%	318	26%
<50	37	16%	194	16%
50–99	20	8%	87	7%
100–499	49	21%	288	23%
500–1,000	16	7%	111	9%
>1,000	31	13%	237	19%
Total	236	100	1,235	100

[a]80 (96%) of these 83 references did not report student-level data analyses or lacked empirical findings altogether. 78 were theoretical papers or literature reviews.

Table 7 Construct Group (Total Reference $N = 236$)

	# of unique references	% of unique	# of coded constructs	% of coded
STEAM	174	74%	383	31%
Expectancy value theory	102	43%	365	30%
Mindsets and social emotional learning	186	79%	473	38%
Other[a]	14	6%	14	1%
Total	n/a[b]	n/a[c]	1,235	100

[a]Includes references not relevant to any of the other construct groups. [b]References received multiple codes when relevant to multiple construct groups. As such, references counted in this column are not necessarily unique by row. [c]Percentages do not add to 100% here because each row was independently calculated as (# / 236)*100.

school, middle school, and elementary school students, respectively. While 38% of the references targeted K – 12 student populations, these accounted for 51% of coded constructs. Considering sample size (Table 6), 80 (96%) of the 83 references lacking such information did not report student-level data analyses or lacked empirical findings altogether. About one-fifth (21%) of the remaining studies reported analyses using samples of 100 – 499 students, with the rest of the literature pool approximately split in terms of working with smaller (24%) and larger (20%) samples.

Construct Group

Table 7 displays both unique reference counts and the number of coded instances by broad construct group (i.e., STEAM, EV, and SEL). Approximately three quarters (74%) of references reviewed were coded as being relevant to STEAM. Slightly more (79%) where coded as relevant to SEL. Fewer references (43%) were coded as relevant to EV theory, although differences in coding rates between the above three construct groups were much smaller, considering the overall number of constructs flagged across the pool of literature. In this context, references to SEL were most common (38%), followed closely by STEAM (31%) and EV (30%). A small subset of references (6%) was also coded as irrelevant to any of the three primary construct groups. Below we report on distributions of specific constructs within each broad construct group and the extent to which these were assessed versus only discussed in the reviewed literature.

STEAM Domains

Of the 174 (74% of 236 total) references coded as addressing STEAM domains (see Table 8), half focused on mathematics or science (49% and 51%, respectively), with 32% (56 references) addressing both of the above content domains. A similar percentage (48%) focused on technology, with fewer articles addressing engineering or the arts (24% and 4%, respectively). Within each STEAM domain, we looked at whether references contained discussion of the domain versus reports of having assessed students on their knowledge or skills in each area. References focused on mathematics or science tended to incorporate student assessments more frequently (43% and 38%, respectively) than those focused on engineering and technology (which assessed students in those areas 24% and 18% of the time, respectively). Of note regarding STEAM domains is that, in all cases, it was markedly more common for references to contain discussion of a given area without the authors having implemented a related assessment activity.

Expectancy Value Theory

As shown in Table 9, of the 102 (43% of 236 total) reviewed references dealing with aspects of EV theory, the three most commonly addressed components were utility value (71% of references), intrinsic value (67%), and expectancy of success (62%). Slightly less common but still mentioned in a majority (>50%) of EV-related references were student goals and attainment value. Fewer references addressed issues of costs and affective reactions as they pertain to EV theory (39% and 16%, respectively). Turning to whether references contained only discussion versus reports of having assessed students on components of EV theory, in contrast to the case above regarding STEAM domains, there were several areas in which assessment was more frequent than discussion alone (e.g., attainment value, intrinsic value, and utility value). The largest gaps between the two activities were found with regard to affective reactions and student

goals, in which only 19% and 25% (respectively) of references mentioning those components contained reports of related assessment activity.

Social Emotional Learning

A wide variety of noncognitive or SEL constructs were discussed or assessed in the reviewed literature (Table 10). Of the 186 (79% of 236 total) references coded as relevant to this area, the two constructs raised most often were motivation (41%) and engagement (38%). These were followed by a group of constructs discussed somewhat less frequently, including communication (26%), self-concept (26%), self-efficacy (23%), teamwork/collaboration (23%), grit/perseverance (19%), and problem solving (17%). Beyond the above, the other constructs tracked were each raised fewer than 10 times across all articles reviewed. Considering the constructs mentioned most frequently and whether the reviewed literature contained only discussion of them versus assessment, in all cases discussion alone was more common than assessment. The split between discussion and assessment activity within the subgroup of constructs most frequently mentioned was largest for communication (87% discussion alone vs. 13% reporting assessment) and smallest for self-schema/self-concept (58% discussion alone vs. 42% reporting assessment).

Crosscutting STEAM and Expectancy Value Theory or Social Emotional Learning

Table 11 summarizes the extent to which literature coded as addressing one or more STEAM domains also dealt with constructs associated with EV theory or SEL. That is, Table 11 shows the intersection between STEAM and both EV and SEL within the pool of reviewed literature. Considering EV constructs first, with the exception of affective reactions or memories (coded only 8% of the time), EV constructs were either discussed or assessed in at least one fifth of STEAM-related references. Three EV components (utility value, intrinsic value, and expectancy of success) were raised in over a third of such references. Parenthetical values in Table 11 represent the percentage of *all* articles coded as related to each construct (i.e., across the entire project) that were also coded as relevant to STEAM. Taking student goals as an example, this construct was coded for 43 references, or 25% of all references relevant to STEAM. These 43 instances also represented 81% of all instances in which student goals was flagged across the entire project (i.e., not limited to STEAM-related references). It is clear that the vast majority of codes for constructs relevant to EV ($\geq$ 87% for all except student goals) derived from articles addressing one or more STEAM domains. This explains why patterns of discussion versus assessment of EV constructs within the reviewed STEAM-related literature followed similar patterns, as shown in Table 9.

Turning to the SEL portion of Table 11 and concentrating on constructs coded 10 or more times, among STEAM-related references, the most commonly coded SEL constructs were motivation (37%) and engagement (32%), followed by self-efficacy (22%), self-concept (22%), communication (21%), and grit/perseverance (20%). Although discussion and assessment of grit/perseverance and self-efficacy across the wider project occurred nearly entirely within the context of the STEAM-related articles reviewed here (100% and 90%, respectively), in general there was less overlap between SEL and STEAM versus the uniformly high levels observed across EV and STEAM. The remaining SEL constructs coded 10

Table 8 STEAM Domains ($N = 174$ Unique References)

	Overall coding[a]		Instances discussed		Instances assessed	
	#	%	#	%	#	%
STEAM general[b]	70	40%	51	73%	19	27%
Science	89	51%	55	62%	34	38%
Technology	84	48%	69	82%	15	18%
Engineering	41	24%	31	76%	10	24%
Arts and/or design	7	4%	5	71%	2	29%
Mathematics	86	49%	49	57%	37	43%

Note. Percentages discussed and assessed were calculated by row. For example (# discussed / # references)*100.

[a]References received multiple codes when relevant to multiple constructs. As such, reference counts and percentages in these two columns do not reflect mutually exclusive subgroups. [b]References containing at least some discussion of STEAM as an overarching domain without a focus on one or more specific areas.

Table 9 Expectancy Value Theory ($N = 102$ Unique References)

	Overall coding[a]		Instances discussed		Instances assessed	
	#	%	#	%	#	%
Affective reactions/memories	16	16%	13	81%	3	19%
Attainment value	52	51%	25	48%	27	52%
Costs	40	39%	24	60%	16	40%
Expectancy of success	63	62%	36	57%	27	43%
Intrinsic value	68	67%	26	38%	42	62%
Student goals	53	52%	40	75%	13	25%
Utility value	72	71%	34	47%	38	53%

Note. Percentages discussed and assessed were calculated by row. For example, (# discussed / # references)*100.
[a]References received multiple codes when relevant to multiple constructs. As such, reference counts and percentages in these two columns do not reflect mutually exclusive subgroups.

or more times in STEAM-related references ranged from those instances capturing 58% (for self-regulation) to 83% (for motivation and stress/anxiety) of their appearances in all literature reviewed across the project. As was the case for EV, patterns of discussion versus assessment of SEL constructs within the reviewed STEAM-related literature followed similar patterns, as shown in Table 10.

Crosscutting Social Emotional Learning and Expectancy Value Theory

Table 12 follows the structure of Table 11, but focuses on the subset of articles coded as relevant to EV within the pool of literature also coded as addressing SEL constructs (irrespective of any connection to STEAM domains). This shows the extent of overlap between EV and SEL constructs within the pool of reviewed literature and, in combination with Table 11, also gives an indication of the overlap between all three content domains (EV, SEL, and STEAM). Reviewing the parenthetical values showing the percentages of all articles coded as related to each EV construct that were also coded as relevant to SEL, it is clear that Table 12 essentially mirrors Table 9. That is, nearly all EV-related references across the project (Table 9) were also coded as relevant to at least one SEL construct. Moreover, it can be inferred that a large

Table 10 Social Emotional Learning ($N = 186$ Unique References)

	Overall coding[a]		Instances discussed		Instances assessed	
	#	%	#	%	#	%
(Achievement) motivation	77	41%	47	61%	30	39%
21st century skills	2	1%	1	50%	1	50%
Action planning	8	4%	5	63%	3	38%
Agency	4	2%	4	100%	0	0%
Communication/social skills	47	26%	41	87%	6	13%
Coping	3	2%	3	100%	0	0%
Engagement	71	38%	45	63%	26	37%
Entity vs. incremental mindset	7	4%	7	100%	0	0%
Grit/perseverance/persistence	35	19%	22	63%	13	37%
Problem solving	31	17%	19	61%	12	39%
Self-awareness	4	2%	4	100%	0	0%
Self-efficacy	42	23%	33	79%	9	21%
Self-regulation/self-control	19	10%	15	79%	4	21%
Self-schema/self-concept	48	26%	28	58%	20	42%
Stress/anxiety	12	6%	7	58%	5	42%
Student learning outcomes	1	1%	1	100%	0	0%
Teamwork/collaboration	42	23%	26	62%	16	38%
Theory of intelligence	6	3%	4	67%	2	33%

Note. Percentages discussed and assessed were calculated by row. For example, (# discussed / # references)*100.
[a]References received multiple codes when relevant to multiple constructs. As such, reference counts and percentages in these two columns do not reflect mutually exclusive subgroups.

Table 11 Expectancy Value and Social Emotional Learning Constructs Coded Within Pool of $N = 174$ STEAM-Related References

	Overall coding[a]			Instances discussed		Instances assessed	
	#	%	(% all in construct)	#	%	#	%
Expectancy value							
Affective reactions/memories	14	8%	(88%)	11	79%	3	21%
Attainment value	51	29%	(98%)	25	49%	26	51%
Costs	35	20%	(88%)	21	60%	14	40%
Expectancy of success	57	33%	(90%)	30	53%	27	47%
Intrinsic value	59	34%	(87%)	21	36%	38	64%
Student goals	43	25%	(81%)	31	72%	12	28%
Utility value	65	37%	(90%)	28	43%	37	57%
Social emotional learning							
(Achievement) motivation	64	37%	(83%)	39	61%	25	39%
21st century skills	1	1%	(50%)	0	0%	1	100%
Action planning	3	2%	(38%)	2	67%	1	33%
Agency	3	2%	(75%)	3	100%	0	0%
Communication/social skills	36	21%	(77%)	32	89%	4	11%
Coping	3	2%	(100%)	3	100%	0	0%
Engagement	55	32%	(77%)	34	62%	21	38%
Entity vs. incremental mindset	7	4%	(100%)	7	100%	0	0%
Grit/perseverance/persistence	35	20%	(100%)	20	57%	15	43%
Problem solving	23	13%	(74%)	14	61%	9	39%
Self-awareness	2	1%	(50%)	2	100%	0	0%
Self-efficacy	38	22%	(90%)	29	76%	9	24%
Self-regulation/self-control	11	6%	(58%)	9	82%	2	18%
Self-schema/self-concept	39	22%	(81%)	22	56%	17	44%
Stress/anxiety	10	6%	(83%)	7	70%	3	30%
Teamwork/collaboration	28	16%	(67%)	20	71%	8	29%
Theory of intelligence	6	3%	(100%)	4	67%	2	33%

Note. Parenthetical values represent the percentage of all articles coded as related to each EV or SEL construct that was also coded as relevant to STEAM. Percentages discussed and assessed were calculated by row. For example, (# discussed / # references)*100.
[a]References received multiple codes when relevant to multiple constructs. As such, reference counts and percentages in these two columns do not reflect mutually exclusive subgroups.

Table 12 Expectancy Value Constructs Coded Within Pool of $N = 186$ Social Emotional Learning-Related References

	Overall coding[a]			Instances discussed		Instances assessed	
	#	%	(% all in construct)	#	%	#	%
Affective reactions/memories	16	9%	(100%)	13	81%	3	19%
Attainment value	51	27%	(98%)	24	47%	27	53%
Costs	38	20%	(95%)	22	58%	16	42%
Expectancy of success	61	33%	(97%)	34	56%	27	44%
Intrinsic value	65	35%	(96%)	24	37%	41	63%
Student goals	52	28%	(98%)	39	75%	13	25%
Utility value	70	38%	(97%)	33	47%	37	53%

Note. Parenthetical values represent the percentage of all articles coded as related to each EV construct that was also coded as relevant to SEL. Percentages discussed and assessed were calculated by row. For example, (# discussed / # references)*100.
[a]References received multiple codes when relevant to multiple constructs. As such, reference counts and percentages in these two columns do not reflect mutually exclusive subgroups.

proportion of EV-related references were relevant to *both* SEL and STEAM, given the high percentages for EV constructs evident in the analogous Table 11 column.

Table 13 is similar to Table 12 but displays data in the opposite direction. That is, Table 13 shows the subset of articles coded as relevant to SEL within the pool of literature also coded as addressing constructs in EV theory. Reviewing the parenthetical values and focusing on constructs coded 10 or more times, there was less overlap here than was observed in

Table 13 Social Emotional Learning Constructs Coded Within Pool of $N = 102$ Expectancy Value-Related References

	Overall coding[a]			Instances discussed		Instances assessed	
	#	%	(% all in construct)	#	%	#	%
(Achievement) motivation	63	62%	(82%)	37	59%	26	41%
21st century skills	1	1%	(50%)	0	0%	1	100%
Action planning	3	3%	(38%)	2	67%	1	33%
Agency	2	2%	(50%)	2	100%	0	0%
Communication/social skills	17	17%	(36%)	15	88%	2	12%
Coping	3	3%	(100%)	3	100%	0	0%
Engagement	47	46%	(66%)	34	72%	13	28%
Entity vs. incremental mindset	4	4%	(57%)	4	100%	0	0%
Grit/perseverance/persistence	29	28%	(83%)	20	69%	9	31%
Problem solving	8	8%	(26%)	6	75%	2	25%
Self-awareness	2	2%	(50%)	2	100%	0	0%
Self-efficacy	37	36%	(88%)	28	76%	9	24%
Self-regulation/self-control	13	13%	(68%)	11	85%	2	15%
Self-schema/self-concept	45	44%	(94%)	27	60%	18	40%
Stress/anxiety	12	12%	(100%)	7	58%	5	42%
Teamwork/collaboration	12	12%	(29%)	9	75%	3	25%
Theory of intelligence	3	3%	(50%)	1	33%	2	67%

Note. Parenthetical values represent the percentage of all articles coded as related to each SEL construct that was also coded as relevant to EV. Percentages discussed and assessed were calculated by row. For example, (# discussed / # references)*100.

[a]References received multiple codes when relevant to multiple constructs. As such, reference counts and percentages in these two columns do not reflect mutually exclusive subgroups.

Table 12. This was taken as an indication that, although EV-related references were essentially a subset of the SEL-related references reviewed in this project, the opposite was not the case across the full range of SEL constructs. In part, this may have just been a function of the project involving a greater number of references coded as relevant to SEL constructs (186) versus EV constructs (102). However, that would not explain the phenomenon entirely because there were no SEL constructs coded 102 times or more (see Table 10), and there were exceptions in which very high overlap was observed (e.g., stress/anxiety, self-schema/self-concept, self-efficacy). Notable also in Table 13 were the relatively low levels of overlap observed for motivation (82%) and engagement (66%), given the direct conceptual ties between these SEL constructs and EV theory.

Discussion

The aim of this project was to summarize metadata across the body of literature reviewed during the first year of a multifaceted research project on STEAM Ecosystems. This work involved subprojects concentrated on conversation-based assessment, digital dashboards, and portfolio-based tasks and observations. Our goals were to highlight crosscutting areas of overlap in the construct space potentially relevant to multiple strands of work and to provide a sense of where there might be gaps in the current body of literature being reviewed in these efforts. Beginning with the development of a standardized reporting structure for describing reviewed literature, detailed information on 236 unique references was catalogued by a team of over 15 staff members across multiple ETS research groups.

Considering descriptive characteristics of the different types of references reviewed, it is notable that fewer than 20% contained reports of experimental studies, with the largest subgroup being purely theoretical in nature or containing only reviews of extant literature. While literature reviews may briefly summarize experimental results, and the distribution of study types observed here may not reflect the true rate of experimental work in the larger body of literature on STEAM (e.g., An, 2013), EV, or SEL, this finding indicates projects under the STEAM Ecosystems framework have been informed primarily by observational, qualitative, or theoretical work to date. This was not considered a problem because several Ecosystems projects were in exploratory phases during their first year, but may speak to a need to delve further into the experimental literature (to the extent it exists) when projects move toward developing interventions. Moreover, ETS's STEAM Ecosystems projects will themselves contribute several new experimental studies to the literature over the next few years.

Also of note was that 38% of the literature reviewed was coded as primarily relevant to K – 12 settings (an additional 17% focused on multiple populations; see Table 5). Presuming all articles coded "multiple populations" addressed K – 12 to some extent, this leaves 45% of the reviewed literature not speaking directly to primary or secondary school students. As with study design, we took this finding as an indication of the potential value of amplifying the focus on K – 12 studies in STEAM engagement research, as is being done in the STEAM Ecosystems work (in which all subprojects are focused primarily on tasks and activities geared toward K – 12 students).

With regard to the construct space under examination in the STEAM Ecosystems work, two general findings are important to highlight. First, as a proportion of the number of times constructs in the STEAM, EV, and SEL spaces were raised at all in the reviewed literature, they were assessed relatively infrequently. That is, assessment activity was reported in fewer than 50% of references in each STEAM domain (Table 8), for five of the seven EV constructs (Table 9), and for all 10 SEL constructs coded 10 or more times (Table 10). This is accounted for in part by the theoretical nature of a substantial portion of the literature organized in this study, but (in the case of EV and SEL) may also speak to gaps in the literature in which the assessment of nonacademic constructs is concerned. Assessing and interpreting these types of constructs in a reliable and valid manner presents a challenge to applied researchers (Duckworth & Yeager, 2015; Lipnevich, MacCann, & Roberts, 2013), and thus we expect the field to be well served by studies such as those whose literature review efforts are compiled and summarized here. Each strand of the STEAM Ecosystems project underway will develop innovative, psychometrically rigorous assessments targeting one or more of the above construct groups.

Our second general finding of note is the extent of overlap observed in the literature between the three major focal areas. Particularly with regard to EV theory, the vast majority of references (i.e., typically near 90% or more; see Tables 11 and 12) flagged for relevancy to EV constructs were also coded as addressing one or more STEAM domains and SEL constructs. While rates of overlap were slightly lower in terms of STEAM-related references also flagged for relevance to SEL, these still covered over 70% of *all* SEL references for eight of the 10 constructs coded 10 or more times (Table 11).

Because literature reviews across STEAM Ecosystems projects were not necessarily comprehensive in scope (i.e., they were targeted to inform specific research questions and may not have considered unpublished sources), we cannot infer that the construct spaces across our three focal domains overlap in the field at large as closely as observed here. It is nonetheless helpful to consider again the parenthetical values in Table 13 to gain a sense of the validity of our construct coding from a theoretical perspective. For example, four of the five SEL construct reference subgroups most highly accounted for by the reviewed EV-related literature (motivation, grit/perseverance, self-efficacy, and self-concept) were those arguably most closely aligned with EV theory among the 17 constructs considered. Moreover, and regardless of the field's overall literature distribution, the fact that there appears to be a substantial body of work cutting across the STEAM, EV, and SEL domains speaks to the utility of forging stronger explicit connections (both theoretical and applied) between these domains in future projects focused on measuring and facilitating student engagement and persistence in STEAM fields.

Two such avenues of work are already underway and represent forthcoming phases of this crosscutting research effort. First, and focused on assessment, the development of new assessments across STEAM Ecosystems (and other previous) work has highlighted a need to document their features to encourage future and more widespread use. Building upon prior work (Steinberg et al., 2011) and following an analogous historic compendium on cognitive testing (Ekstrom, Dermen, & Harman, 1976), we are cataloguing instrument content and adding metadata for SEL and other types of related measures (e.g., those targeting EV constructs, STEAM domains, or both) created by or used at ETS and going back nearly two decades. This will result in the development of a searchable assessment database containing detailed information on a wide variety of tools making use of multiple item types and addressing 200+ constructs. Our goal is to design a tool enabling researchers conducting assessment efforts in SEL, EV, STEAM (and potentially additional areas) to track, standardize, and coordinate them across studies. This will open opportunities for cross-study analyses and comparisons, making close collaboration more feasible and informative across diverse ETS projects and staff.

Facilitated by both the current literature review summary and above-mentioned assessment database, the second phase of future work will be to evaluate EV theory as a holistic model (e.g., Eccles & Wigfield, 2002) capturing each of its major theoretical components using rigorously developed assessment tools. Although there are examples of holistic meta-analytic models incorporating central elements of EV theory (e.g., Colquitt, LePine, & Noe, 2000; Robbins, Oh, Le, & Button, 2009), it is difficult to locate studies focused on K – 12 education testing its framework using high-quality

assessment applied across the range of key constructs (see Table 1). Later stages of this work are planned to capture longitudinal shifts in students' expectations and values, providing a sense of the malleability of these constructs as (for example) incentives or rewards shift within a given educational context.

Within existing STEAM Ecosystems research at ETS, this study has established a structured basis for summarizing diverse literatures and encouraging meaningful collaboration across varied STEAM Ecosystems (and other STEAM-related) projects. Our goal is to expand the strategies used here to generate further research applying high-fidelity assessment tools to pressing research questions informed by applicable theory. To that end, tools derived from this work were designed to nudge the field toward more impactful, generalizable studies seeking to inform what works to support students in their pursuit of engaging and productive STEAM engagement, regardless of whether those activities trend toward educational or career-oriented outcomes.

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