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U.S. Parents' Scientific Literacy and Efficacy: Associations with Children's STEM Media Engagement

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Abstract

Promoting science, math, engineering, and technology (STEM) skills for young children provides foundation for and interest in later STEM learning, making early childhood an important time to develop these competencies. Young children also spend increasing amounts of time with media, and thus it is important to understand if children are accessing STEM content and what factors may determine this access. The current survey study of parents of three- to seven-year olds assesses how parents' science self-efficacy and parents' scientific literacy relate to children's STEM media use. Results demonstrate positive relations between parent self-efficacy and child STEM media use (aligned with self-efficacy theory), but results also demonstrate no significant relation between parent scientific literacy and child STEM media use. We conclude that parent self-efficacy is an important social susceptibility for young children's STEM media use and that future research should continue exploring potential interventions for promoting parents' self-efficacy related to teaching their children science.

Keywords: STEM media, parent efficacy, scientific literacy, preschoolers

Impact Summary

Prior State of Knowledge: Little research has examined the relations between parents' perceived beliefs that they can teach their children science and children's engagement with STEM media. Children spend increasing time with media; thus, we should understand how to leverage this time for learning.

Novel Contributions: The current study demonstrates that parents' beliefs that they can teach their children science are positively associated with children's STEM media use. However, parents' scientific literacy was not associated with children's STEM media use.

Practical Implications: To get children to use more STEM media, interventions should focus on parents' beliefs that they can teach their children STEM concepts, such as science. Parents influence children's media use, and intervening with parents can help shape children's media diets in positive ways.

U.S. Parents' Scientific Literacy and Efficacy: Associations with Children's STEM Media Engagement

Scientific literacy, or the ability to use scientific knowledge and reasoning to make decisions, is important for creating robust democratic societies and meeting the civic demands of the workforce (Pearson et al., 2010). At early ages, children can and should start learning foundational science skills. Parents can teach these skills, and children can also learn them from media (Aladé et al., 2016; Bonus, 2019). Parents might engage with their children in informal science activities that take place outside of school, such as cooking, visiting a science museum, or gardening. They might also engage with their children by having them watch science media such as *Octonauts* or *Tumble Leaf*. Indeed, parents' attitudes and personal characteristics have influence on which media and informal STEM activities their young children (3-7 years old) have access to (Pila et al., 2021; Sheehan et al., 2018).

There is limited research, however, on how parent characteristics relate to parents' engagement with science media with young children. Characteristics of theoretical and practical importance include parents' self-efficacy as related to supporting children's science learning (self-efficacy theory) as well as general scientific literacy. Theory posits that children's social susceptibilities, or factors in children's social context that affect their uses of and responses to media, predict their media experiences and effects thereof (Valkenburg & Peter, 2013). Therefore, we conducted a survey study of parents of three- to seven-year-olds (N = 260), as this age range captures the period right before a developmental switch into middle childhood but after toddlerhood. In this manner, early childhood allows children to exert some autonomy, but they still require much parental guidance. Capturing this transition period between toddlerhood and middle childhood can aid our understanding of how parents influence children's media use,

particularly when they still have more oversight over their children's activities. Parents responded to items about self-efficacy related to teaching their children science, scientific literacy, and STEM (science, technology, engineering, and math) media use.

Theoretical Background

We consider both the Differential Susceptibility to Media effects Model (DSMM) and self-efficacy theory as theoretical backgrounds for the current study, such that parents' self-efficacy can serve as a social susceptibility for young children's media use. The DSMM framework hypothesizes that a person's media experiences are determined by social, developmental, and dispositional features in their environments (Valkenburg & Peter, 2013). Here, we focus on how social susceptibilities are associated with determinants of young children's media access. The current study considers how parent demographics, like gender and parent attitudes relate to young children's media use. While these are dispositional features for parents, they are also part of children's social susceptibility to media, in that the developing child lives within the social environment created, in part, by their parents. We specifically consider parent self-efficacy in teaching their young children science as a piece of children's social susceptibility. Bandura's self-efficacy theory suggests that all psychological and behavioral change occurs through one's sense of efficacy, or perceived capability. According to self-efficacy theory, people regulate their own behaviors and expend effort based on their perceived self-efficacy, or sense of self-mastery (Bandura, 1977). Thus, self-efficacy theory would suggest that parent self-efficacy, as related to science, would determine how parents choose to introduce their children to science media, and the DSMM would suggest that parent self-efficacy is one potential factor of children's social susceptibility to media.

Parent Self-Efficacy in Science and Math

Parent self-efficacy as related to STEM learning has focused on math skills, rather than science learning (for exceptions, see Hightower et al., 2021; Silander et al., 2018). Studies on parent math efficacy and child outcomes demonstrate that anxiety, or fear, around math among parents can negatively affect young children's math learning (Vukovic et al., 2013). These findings may translate to science learning, but parents are less confident in their abilities to teach science to their young children, as compared to math or reading literacy (Silander et al., 2018). There is some evidence, however, that self-efficacy in teaching science is related to more frequent engagement in informal science activities, including science media use (Hightower et al., 2021). As media use becomes a more common activity for young children, it is likely that parents' self-efficacy will relate to various types of media use, like for non-media activities. Thus, we hypothesize:

H1: Greater science self-efficacy for parents will be associated with greater STEM media use for children.

Scientific Literacy

In addition to science self-efficacy, the current study investigates parents' scientific literacy as another potential determinant for young children's STEM media use. Scientific literacy does not have an agreed-upon and universally accepted definition, and some scholars argue that such a definition would be impractical (Laugksch, 2000). We primarily consider scientific literacy to be a parents' ability to use and apply foundational knowledge to a content assessment quiz. Thus, parents who are more knowledgeable about science might also be more confident in their own abilities to teach it to their young children, but past research has demonstrated that a family member having a STEM career (which would likely mean that they are highly scientifically literate) negatively predicts (Sheehan et al., 2018) or is not related to

STEM media use among children (Pila et al., 2021). Self-efficacy theory suggests that behaviors and behavioral change are determined by efficacy (rather than skill), but self-efficacy and scientific literacy might be closely related, suggesting that scientific literacy may have a positive relation to STEM media use. Thus, we pose a question:

RQ1: How does parent scientific literacy relate to children's STEM media use?

Method

Participants

Participants included parents of three- to seven-year-olds in the United States from Amazon's Mechanical Turk (MTurk) in December 2022. Two-hundred-ninety-one participants completed the survey. Participants who missed more than two attention check questions were excluded (n = 31). The final sample included 260 participants. Eighty-six percent of the sample was White (n = 224), 6.92% Asian (n = 18), 0.38% Black (n = 1), and 0.77% American Indian or Alaskan Native (n = 2). Additionally, 1.82% of participants selected more than one option for race (n = 5), 1.92% wrote in another option (n = 1), and 3.46% declined to answer (n = 9). Fifty-eight percent of the sample was fathers (n = 151; 38.08% percent mothers, n = 99; 0.38% non-binary parents, n = 1; 3.46% declined to answer, n = 9). The sample was highly educated (90.00% of participants had a college or advanced degree, n = 234). The median income bracket of the sample was $50,000-$74,999. Parents reported on only one child in their household between the ages of 3 and 7 (M = 4.62 years; 68.08% boys, n = 177; 28.08% girls, n = 73; 0.38% self-described, n = 1; 3.46% declined to answer, n = 9). Participants who had more than one child in this age range were asked to answer questions about the child whose birthday came next.

Measures

Measures included items to assess parent scientific literacy and efficacy as well as engagement in informal science learning and STEM media content with children. A list of measures has been included in the Supplementary Materials.

Informal Science and Math Activities

To assess parents' general engagement with STEM with their children, we first asked parents to report how often they engaged in informal STEM activities, such as playing with blocks, adapted from Hightower et al. (2021). Parents noted whether they had engaged in the activity with their child over the past 30 days. If they had, they then reported how many times they engaged in this activity during this time period. Instances of engagement were summed to create a monthly informal STEM engagement score (M = 39.96, SD = 32.04). Parents also reported whether their children engaged in four other STEM activities, such as attending a science or math camp, on an annual basis. Items were summed to create an annual informal STEM engagement score (M = 2.54, SD = 1.34).

Parent Science Efficacy

To measure self-efficacy as it relates to teaching young children science, we adapted a questionnaire that was originally used with preschool teachers (Maier et al., 2013). Parents responded to 10 items about their own efficacy as related to teaching their young children science, such as "Planning and demonstrating hands-on science activities is a difficult task" (reverse-coded). Responses ranged from *1 – Strongly Disagree* to *5 – Strongly Agree*. Internal consistency was acceptable (α = .83); items were summed to create a parent science efficacy score (M = 13.75, SD = 4.32).

Scientific Literacy

Scientific literacy was measured through six questions taken from the California Science Test (California Assessment of Student Performance and Progress, n.d.) and the New York state science tests (New York State Education Department, n.d.) at the fourth, fifth, and eighth grade levels. Two questions were from the New York Regents High School Examination science tests (Office of Statement Assessment, n.d.). Two additional questions from a Pew Research Center study on Americans' scientific literacy (Kennedy & Hefferon, 2019) were included due to high levels of performance during a pilot test of the initial items. Ten questions were included in the final measure. Items were summed to create a scientific literacy score of number of correct answers (M = 3.70, SD = 1.83). See Supplementary Materials for correlations between each item and information on where each item can be accessed.

STEM Media

Parents also responded to questions about which shows or videos and applications (apps) their children watched and used the most. Parents were asked to report their children's favorite two shows/videos/channels as well as their child's two favorite apps. These responses were then compared to Common Sense Media's (a company that reviews children's programming) list of science shows and apps. Common Sense has reviews for 8,260 television shows and has tagged 539 of these shows as related to STEM. Additionally, they have reviewed 4,422 apps with 443 being tagged as related to STEM.

Parents also responded to five questions about how often their children engaged with both science and math media over the past 30 days (e.g., "How many times has your child played with science apps over the past 30 days?"). These items had acceptable internal consistency (α = .74) and thus were summed to create an informal STEM media engagement score (M = 17.93, SD = 18.85).

We included both of these measures to better capture children's media diets. The opaque measure (children's favorite shows and apps) was included to see what children watched most frequently while the transparent measure was included to be consistent with past research and to see if there were potential issues with parents underreporting STEM media use (Hightower et al., 2021). Further, children may watch other shows aside from their two listed favorites, and thus having parents report on type of content in this manner may better inform our understanding of children's general media use.

Analytical Approach

Data were analyzed using a hierarchical linear regression. We tested potential covariates (parent race, parent age, child age, parent gender, child gender, parent educational attainment, marital/co-habitation status, and household income) for significant correlations with both the independent and dependent variables (see Table 1). All variables except for household income and marital/co-habitation status were significant with at least one variable of interest and thus included as covariates. These covariates were used in the first step of the hierarchical linear regression predicting informal STEM media use. The second step of the regression added informal STEM activities to further control for parents' general STEM engagement. We added in these variables as they had significant correlations with STEM media use (annual: $r = 0.18$; $p = 0.004$; monthly: $r = 0.63$, $p < .001$). The third step included parent scientific literacy (RQ1). The fourth and final step of the regression added parent science efficacy (H1). We entered these on separate steps to allow us to examine their individual contributions to the overall model.

TABLE 1 ABOUT HERE

Results

Descriptive Results

Our original intention was to use parents' reports of specific STEM shows and apps as our outcome variable. However, parents reported so few STEM shows and apps in the open-ended question that there was not enough diversity to use these reports. Out of 304 parent reports of children's favorite shows (inclusive of repeated shows), none were tagged as STEM shows by Common Sense Media. Out of 277 parent reports of children's favorite apps, only 15 were tagged as STEM apps by Common Sense Media. Thus, we instead used parents' report of how frequently they used STEM media with their children over the course of one month (M = 17.93, SD = 18.85) as the dependent variable. We discuss the implications of this finding below.

Regression Results

The regression model predicted average monthly STEM media use (see Table 2). The initial model included significant covariates (parent race, parent age, parent gender, child gender, and parent educational attainment). The first block was not significant (R^2 = 0.03, F(6,242) = 1.12, p = .35). Informal STEM activities (both annual and monthly) were added in the next step of the regression. The overall model was significant (R^2 = 0.42, F(8,240) = 0.42, p < .001), with a significant addition of explained variance (ΔR^2 = .39, ΔF(2,240) = 144.08, p < .001). Informal monthly STEM activities (β = .62, p < .001) and informal annual STEM activities (β = .11, p = .03) were significantly related to average monthly STEM media use. The third step added parent scientific literacy. The overall model was significant (R^2 = 0.42, F(9,239) = 19.16, p < .001), but there was not a significant addition of explained variance. Scientific literacy was not significantly related (β = 0.003, p = .96; RQ1). The final step of the model included parent science efficacy. The overall model was significant (R^2 = 0.43, F(8,238) = 17.92, p < .001) with a significant addition of explained variance (ΔR^2 = .01, ΔF(1,238) = 2.59, p = .04). Parent science efficacy was significant (β = 0.11, p =.04), supporting H1.

TABLE 2 ABOUT HERE

Discussion

The results of this survey of parents of 3-7-year-old children demonstrate that parents' science efficacy and informal monthly/annual STEM activity engagement relate to how often they use STEM media with their children. We also found that parent scientific literacy was not significantly related to STEM media use, consistent with some previous research (Pila et al., 2021).

Theoretical Implications

The current study builds upon prior knowledge of how parent science efficacy relates to STEM media use with young children and adds the component of measured scientific literacy. Our results demonstrate that self-efficacy (Bandura, 1977), but not scientific literacy, plays a role in how parents influence their young children's media use. Past research has demonstrated non-significant findings with regard to parents' STEM careers and children's STEM media use (Pila et al., 2021). Here, we measured scientific literacy directly but found the same null relation. Other research has shown a negative association between these variables (Sheehan et al., 2018), and thus further exploration is needed. Our positive finding about self-efficacy and STEM media use, however, does align with self-efficacy theory and demonstrates how parent dispositional susceptibility to media use can also influence children's social susceptibility to media use (Valkenburg & Peter, 2013). Our findings thus indicate that promoting parent self-efficacy may be more important than focusing on parents' actual skills, at least as they relate to teaching their children science. In other words, parents do not need to excel in STEM to help their children learn, they just need to feel that they are capable of this teaching. Future research can examine how parent self-efficacy may relate to other STEM activities.

Practical Implications

The practical implications of the current study relate to both research and practice on young children's STEM learning.

Implications for Research

First, our initial measure of STEM media use did not yield diverse enough results to conduct analysis. When parents were transparently asked about their science and math media use, they reported, on average, that children used this type of media every other day. However, when parents were asked more opaquely about their children's media habits (i.e., "What is one of your child's favorite shows/channels/videos"), zero shows and 15 apps related to STEM were reported. Past research has demonstrated that parents not only struggle to identify STEM media (Hightower et al., 2021), but parents also struggle to identify science activities with their children generally (Silander et al., 2018). These struggles may explain the discrepancy in our findings between the opaque open-ended questions and the transparent closed-ended questions. However, this past research demonstrates that parents under identify these activities, rather than overidentify. In this way, we assumed that parents would be using STEM media with their children but not recognize it, but instead we found that parents may think that their children are using STEM media when they are not.

It is also possible that children use such a diversity of media that STEM apps and shows were not among the most liked. The list of shows and apps that parents reported can be found in our supplementary files. A full content analysis of these shows and apps is outside of the scope of this research brief, but we found that the majority of content reported was not classified as educational by Common Sense Media. Of the 147 unique responses on children's favorite shows, 107 of these were cataloged by Common Sense Media. Of those 107, 0 were STEM shows, 19

were tagged as educational, and 15 were tagged as related to friendship (prosocial outcomes). The top three shows reported on in our sample were *Our Cartoon President* (*n* = 13), *Peppa Pig* (*n* = 13), and *The Dodo Kids* (*n* = 8). Of these shows, none of them are tagged as educational or related to friendship. To reiterate, parents reported on their children's favorite shows, not all of the shows that children watch, and we used this measure as a proxy for what children are most likely to watch.

We included both the transparent and opaque measure of content to better capture children's media diets. The opaque measure is limited, such that parents only reported two out of the likely many shows and apps that their children use. The transparent measure is limited in that responses may be affected by social desirability. We have no reason to suspect, however, that social desirability would more greatly affect parents who are more efficacious in teaching their children science. Self-reports are a common limitation in media effects literature (Parry et al., 2021), and we included two measures as a safeguard to ensure we could capture children's media diets.

We interpret the discrepancy between these measures as a function of media classification, rather than inaccurate reporting. As we have noted, television shows have many episodes, and while in general shows may not focus on STEM, educational outcomes, or prosocial outcomes, it is possible that these shows have themes in select episodes that children are watching. Common Sense Media's reviews are written primarily for parents who are making decisions about what their children should watch. While these reviews can be useful for researchers to understand children's media diets, they miss nuance. Thus, children's engagement with STEM content may be as frequent as reported, but this content may also be mixed with other curriculum like social-emotional learning or literacy. Researchers have struggled to

develop measures that assess the *type* of content that people consume. Here, we attempted a potential way to address this issue, but future research should continue exploring these possibilities.

Implications for Practice

Moreover, our findings suggest that improving parent science efficacy, but not literacy, can encourage parents to use more STEM media with their children, potentially influencing children's STEM skills (e.g., Aladé et al., 2016; Bonus, 2019). The age range of our study (3-7) captures a developmental period that extends from preschool to early childhood. During this time, children are gaining more autonomy yet still require parental guidance. Further, building STEM skills during this developmental period can help children achieve later success in STEM learning (Clements et al., 2016). Because parents still exert some control over their children's media use during this transition period, it is possible that parents are one potential avenue to promote STEM learning.

Practitioners, such as preschool teachers and pediatricians, might target parents' self-efficacy related to teaching their children STEM and encourage parents to engage in informal STEM activities with their child including STEM media content. Specifically promoting positive beliefs in parents that they can teach their children science, may make parents more likely to engage their children in STEM activities. Further, media makers can integrate material targeting parent self-efficacy within their designs. Some apps, such as *Khan Academy Kids*, have resources for parents, such as instructions for using the app or tips for using media. These resources, however, do not often have language targeting parent self-efficacy to bolster parents' confidence in their STEM teaching abilities, and including this language may have positive effects on child engagement.

Strengths, Limitations, and Future Directions

One strength of our study includes our operationalization of scientific literacy. Though this construct has been assessed through surveys before (Kennedy & Hefferon, 2019), questions often require base content knowledge that disadvantages people who can reason about science but might not have the background information required for a knowledge-specific question. We instead employed questions that did not require prior content knowledge so that participants could reason through each question. Distribution of scientific literacy scores was normal, and thus this study contributes a style of scientific literacy measure that can be used in surveys with adults. Further, we adapted a measure of science efficacy meant for preschool teachers (Maier et al., 2013) to be appropriate for parents. Our version of the measure had acceptable internal consistency, and thus these items could be used in future studies. For these reasons, the current study contributes to literature on both scientific literacy among parents and susceptibilities of media use.

Our results should be considered alongside our study's limitations, however. We have already discussed issues with self-reporting above, and thus we focus on other issues in this section. First, most of our participants were White and highly educated. Less than 15% of our sample identified as a race other than White, and 90% of parents of participants had a college degree or higher. Though we do not have reason to suscept differences among parents solely based on race or education educational attainment, past literature on media and education do suggest that attitudes may vary by race and educational attainment. For example, Black and Hispanic parents (relative to White parents) report more positive attitudes toward the idea that young children can learn from media (Rideout & Robb, 2020). Thus, future studies should have more racially diverse samples to address potential variability.

Additionally, parents who are more highly educated may be more confident in their abilities to teach their children science. Though parent education and parent self-efficacy were not significantly correlated in our data, parent education and income were significantly correlated, and parent media attitudes do vary by income (Rideout & Robb, 2020). Additionally, we did not collect information about parents' specific careers. Past research demonstrates mixed findings as to whether a family member having a STEM career affects STEM media use (Pila et al., 2021; Sheehan et al., 2018), but future research including this variable could help further our understanding of how the family context shapes STEM media use. Further, our study is cross-sectional, thus we cannot make claims about directionality. It is possible that parent science efficacy promotes STEM media use or that STEM media use promotes parent science efficacy, and longitudinal research could identify these directions.

Future research should continue to examine measuring content type, experimental interventions aimed at parent science efficacy, and further assessment of for whom greater science efficacy matters in terms of promoting STEM media use. First, researchers should continue to identify ways to classify the content children consume. Here we attempted to use industry classifications of content, but we may have missed nuance (such as certain episodes relating to STEM). Second, researchers should use longitudinal surveys to assess the direction of the relation between parent science efficacy and child STEM media use. Interventions designed to promote parent science efficacy can better demonstrate the relation between parent efficacy and child STEM media use, contributing to our understanding of children's social susceptibilities to media. Finally, once directionality is understood, researchers should identify for whom these interventions matter. Future research should address these relations directly to identify the best

ways to categorize media content, the directionality, and the profiles of parents who might benefit from intervention to promote STEM media use.

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Table 1
Correlations

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Parent Race													
2. Child Race	.98**												
3. Parent Age	-.11	-.10											
4. Child Age	-.07	-.07	.37**										
5. Parent Gender	-.05	-.06	.06	-.03									
6. Child Gender	-.08	-.08	-.03	.00	.25**								
7. Parent Education	-.19**	-.19**	.04	-.08	.06	-.02							
8. Income	-.23**	-.24**	-.02	-.05	.10	.09	.28**						
9. Marital/Co-Habitation Status	-.30**	-.31**	.10	-.02	.10	.11	.15*	.05					
10. Science Efficacy	-.13*	-.16**	.10	-.06	.16*	.15*	-.03	.10	.08				
11. Scientific Literacy	-.18**	-.20**	.19**	.16**	-.02	.02	-.17**	.08	.07	.20**			
12. Informal STEM (annual)	.01	.04	.02	.08	-.05	-.02	.14*	-.04	-.01	-.29**	-.22**		
13. Informal STEM (monthly)	-.11	-.12	-.10	-.13*	.00	-.06	.08	-.03	.06	-.08	-.02	.11	
14. STEM Media (monthly)	-.08	-.09	-.06	-.05	.02	-.09	.07	-.03	.06	.03	-.03	.18**	.63**

Note. Race was coded such that white parents were assigned a value of 1 and Hispanic/Latino, Black/African American, Asian, Native Hawaiian/Pacific Islander, and American Indian/Alaska Native parents were assigned a value of 2. Gender was coded such that boys/men received a value of 1 and girls/women received a value of 2. Parents who were married, engaged, or co-habituating with a partner were assigned a value of 1. Other relationship statuses were assigned a value of 0.

Table 2

Results

Independent Variables	Children's STEM Media Use			
	Model 1	Model 2	Model 3	Model 4
(Intercept)	0.49	0.15	0.15	0.18
Parent Education	0.05	0.006	0.01	0.007
Parent Gender	0.08	0.07	0.07	0.04
Parent Age	-0.06	-0.01	-0.008	-0.02
Child Age	-0.04	0.01	0.01	0.03
Child Gender	-0.23	-0.13	-0.14	-0.16
Parent Race	-0.27	-0.07	-0.07	-0.03
Informal STEM (monthly)		0.62	0.62***	0.62***
Informal STEM (annual)		0.11	0.11*	0.14*
Parent Scientific Literacy			0.003	-0.01
Parent Science Efficacy				0.11*
R^2	0.03	0.42	0.42	0.43
ΔR^2		0.39***	0.00	0.01*

*$p < .05$, **$p < .01$, ***$p < .001$

Note: Race was coded such that white parents were assigned a value of 1 and Hispanic/Latino, Black/African American, Asian, Native Hawaiian/Pacific Islander, and American Indian/Alaska Native parents were assigned a value of 2. Gender was coded such that boys/men received a value of 1 and girls/women received a value of 2.

Biographical Note

Allyson L. Snyder (M.S) is a doctoral candidate in the Department of Communication at the University of California, Davis. She researches how children learn STEM skills (science, technology, engineering, and math) from interactive media, including virtual reality. Allyson also researches the role of parents in children's media use as well as the intersection of media use and self-regulation.

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Alexis Patterson Williams (Ph.D.) is an associate professor at the University of California, Davis. Dr. Patterson Williams's research lies at the intersection of equity studies, social psychology, and science education. Her work explores 1) equity issues that arise from social hierarchies in science classrooms and 2) teacher development of practices that support equitable and robust interactions between students that can deconstruct implicit and explicit language and literacy hierarchies.

Disclosure Statement

No potential conflict of interest was reported by the authors.