The Relation Between Interest and Self-Regulation in Mathematics and Science

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Students' ability to maintain motivation while learning science and math is critical to mastering material beyond the elementary level, and to persisting in the field. It requires not only keeping one's "eyes on the prize," but experiencing interest during the process. However, formal educational curricula typically dictate the types and sequences of materials that must be learned, regardless of how interesting a particular student might find that material. Thus, to persist, students must be able to maintain their motivation even when they do not find the experience interesting. Students are typically encouraged to engage in strategies that (re)emphasize the importance of persistence and likelihood of success, but this may not be enough to counter the pull of more interesting choices. However, students can also engage in strategies that make the experience more interesting, and they are more likely to do so when motivated to persist. Thus, students regulate their experience not just to feel better; they do so to maintain motivation to reach their goals. In this chapter, we describe the Self-Regulation of Motivation model, which outlines how the experience of interest is embedded within the overall process of regulating motivation and behavior. The model synthesizes research detailing how goal striving affects the experience of interest, along with research on whether and how individuals regulate the interest experience. The model also illustrates how the relationship between regulating interest and performance might result in trade-offs, particularly in the short term (e.g., time spent on something that makes learning more interesting might come at a cost to time spent on completing required tasks). The degree to which short-term trade-offs are acknowledged and accepted may, in turn, determine whether students persist in the long term. By exploring how the experience of interest and its regulation work within the overall process of self-regulation, the model suggests ways that educators and the educational context could unintentionally hinder interest regulation, as well as places where they could foster successful regulation. We identify some of these routes as well as some unanswered questions raised by considering interest and its regulation as integral to maintaining motivation over time.

Larry, Emily, and Lucia are undergraduates faced with the same assignment in a computer programming class. At their respective homes, they each sit down in front of their computers and open up the assignment. Larry looks at it for a while and then goes to a video-streaming site and watches a show his friends were talking about. He figures he'll get back to the assignment "later," although he ends up falling asleep and never does. Emily looks at the assignment and reminds herself about how important it is to get a good grade on the assignment so that she can maintain her grade point average. She figures out which parts of the assignment are required, works on those, and finishes as soon as she can. She then shuts down the computer and goes on to do other things. Lucia looks at the assignment and thinks about how it would be useful for creating her own website. She starts working on the assignment, plays with some examples, and tries to use some of what she is learning to design a logo. She e-mails that to a friend to see what he thinks, and reworks the logo on the basis of his suggestions. She then goes back to the assignment, although at that point she doesn't have much time and races through the rest before submitting it.

Although composites, these three example students reflect patterns we have found in our research. From the instructor side, which of these students would be typically considered the "good" student? Larry is the classic "unmotivated" student, easily pulled away by the more interesting things in his environment. Emily, in contrast, is highly motivated to attain her achievement goal of getting good grades, and focuses her attention and efforts on the parts of the learning activity that will garner that achievement. She does not allow herself to be distracted by nonrequired or unrelated activities, and she might be the poster child for effective self-regulation. Lucia, in contrast, would be typically described as distracted by the parts of the activity that are not required and as going off task when sharing logo ideas with a friend. As a result, she does not leave herself enough time to work on the parts of the assignment that are required and on which she will be evaluated. Thus, although she clearly has some motivation to learn the material, she appears to need help in terms of optimizing self-regulation.

If, instead of focusing on how well these students did on the assignment, we ask who is more likely to continue learning in the future, a different picture might emerge as to optimal self-regulation. For example, Emily stopped engagement with the activity as soon as she completed what was required to reach her achievement goal. Lucia, in contrast, might not really be "distracted," but instead might be regulating her motivation to learn by making the experience of learning more interesting. Thus, exploring interesting (though not required) aspects of the activity and sharing what she is learning with friends might make the process of learning more interesting, and thereby keep her learning even after grades on a particular assignment are received.

In our work with college students, we have asked how the experience of interest might be embedded in the process of self-regulation over time. This approach has led to questions about how the nature of students' goals and goal striving affects interest, how interest affects goal striving, and what happens within the process of goal striving when interest lags or is missing. We focus on the motivational properties of the experience of interest, whether currently experienced or the expectation of its experience in the future, as well as on students' active efforts to create and maintain this experience over time. We next provide a brief overview of the theoretical framework from which we work, before describing specific applications to learning science, technology, engineering, and mathematics (STEM).

Conceptual Framework

Models of self-regulation (e.g., Pintrich, 2000) typically include motivation defined in terms of goals. In our opening example, all three students were faced with the same assignment, but they might not have held the same goals. From these perspectives, students will be motivated to engage in an activity (e.g., the assignment) when they see it as a means to achieve some desired outcome (e.g., getting a good grade, mastering a skill) or to avoid an undesired outcome (e.g., failing). The degree of motivation will vary as a consequence of how much they value that outcome and expect to attain it (e.g., Eccles, 1983; Schunk, 1991; Wigfield & Eccles, 2000). In our example, although the nature of Emily's and Lucia's achievement goals might have differed, they both had enough motivation to begin the assignment. In contrast, Larry did not have enough to even begin.

According to most self-regulation models, subsequent motivation depends on the evaluation of progress, and that evaluation can arise from internal or external sources. For example, Emily might evaluate progress on the basis of how much of the required materials she has completed within a particular time frame, whereas Lucia might evaluate progress on the basis of her friend's feedback. Depending on the evaluation, students may continue to be motivated to work toward a goal, or cease to be motivated and stop working (because they either achieved the goal or gave up on the goal). When affect or emotions are included in these models, they are seen as consequences of this evaluative process. For example, according to Carver and Scheier's (1990) control theory model, if students perceive greater progress toward their goals than the standard used for evaluation, they experience positive affect. If rate of progress is slower, in contrast, they experience negative affect. The model proposes that negative affect leads to greater subsequent effort to reach the goal, whereas positive affect leads to decreased effort.

The emphasis in most self-regulation models has thus been on what researchers have labeled "extrinsic motivation" (i.e., motivation to engage in an activity because it is a means to an end) and on the metacognitive variables that contribute to this goal-striving process, such as goal setting, construction of and choice of strategies to reach goals, standards used to evaluate progress, and so on. More recently, however, researchers have begun to expand investigations beyond extrinsic motivation and metacognitive processes to examine emotional and affective variables in more complex ways (e.g., Efklides, 2011; Linnenbrink, 2006; Pekrun, Goetz, Titz, & Perry, 2002). In particular, there is growing recognition that in addition to monitoring progress toward goals, an important part of the self-regulation process involves monitoring how we feel (e.g., Efklides & Petkaki, 2005; Krapp, 2005). Although often tied to evaluations of progress and success in reaching goals, it is not always so (Pekrun & Linnenbrink-Garcia, 2012).

For example, in our work we focus on the phenomenological experience of interest. Interest has been identified by a number of theorists (e.g., Frijda, 1986; Izard, 1977) as a basic emotion that is distinct from general positive mood. For example, Izard (1977) identified interest as a positive emotion that motivates exploration and suggested that interest is one of the more frequently experienced emotions. Building on Izard's work, Fredrickson (1998) suggested that by motivating exploration, interest leads a person to have new experiences (broaden), which in turn lead to greater knowledge about the object of exploration (build). This proposed sequential relationship is consistent with Hidi and Renninger's (2006) Four-Phase Model of Interest Development, which describes how interest can develop within a person from a momentary reaction to stimuli to well-developed individual interests in a topic or domain (for reviews, see Hidi & Renninger, 2006; Renninger & Hidi, 2011).

In a related vein, Silvia (2006, 2008) identified interest as one of the "knowledge" emotions, describing distinct appraisal patterns (novelty-complexity and comprehensibility) that are associated with interest. Strengthening the connection between interest and self-regulation, Connelly (2011) identified goal relevance as a third dimension of interest's appraisal structure. Interest can serve as a source of task value (e.g., Hidi & Renninger, 2006; Wigfield & Eccles, 2000), and although considered a positive emotion, interest can at times be associated with negative feelings (e.g., when experiencing frustration while attempting to figure out some puzzle or when viewing a disturbing image) (e.g., Hidi & Harackiewicz, 2000; Turner & Silvia, 2006). The combination of attentional, cognitive, and affective components that constitute the experience of interest make it distinct from other positive emotions (e.g., happiness) and from general positive mood. For example, the experience of interest can replenish depleted resources to a greater degree than the experience of positive affect more generally (Thoman, Smith, & Silvia, 2011).

The experience of interest is thus a dynamic state that arises through an ongoing transaction among goals, context, and actions (Sansone & Smith, 2000). When motivated by the experience of interest, individuals are more likely to choose initially to work on an activity, persist longer, and reengage in similar activities in the future. Traditionally, this motivation has been labeled "intrinsic motivation" (Deci & Ryan, 2000; Sansone & Harackiewicz, 2000).

Rather than conceptualizing individuals as being intrinsically motivated (i.e., motivated by current or anticipated experience of interest) or extrinsically motivated (i.e., motivated by potential outcomes), the Self-Regulation of Motivation (SRM) model (Sansone & Harackiewicz, 1996; Sansone & Smith, 2000; Sansone & Thoman, 2005) embeds interest within the self-regulation of behavior over time (see Figure 1). Once individuals have begun an activity (e.g., working on the assignment), an important self-regulatory task is to determine whether to continue. To maintain engagement, students must be able to maintain motivation. The SRM model suggests that maintaining motivation involves strategies that address motivation defined in terms of reaching desired (or avoiding undesired) outcomes and strategies that address motivation defined in terms of the experience. In our opening example, although Emily had enough motivation to complete the assignment, because she did not allow herself to do anything that might have made working on the assignment more interesting, she may have less motivation to continue learning. This becomes a problem when learning requires incremental engagement over time, as when mastering and persisting in a field.

Once we recognize motivation regulation as a distinct regulatory demand, it becomes clear that we need to distinguish between initial actions that are directed by students' goals as they begin the activity, and actions that emerge once they have engaged in the activity (maintenance actions). Maintenance actions include actions in service of goals-defined motivation and goal attainment (e.g., looking at an example of programming code in order to do the assignment), and actions in service of the interest experience (e.g., playing around with that programming code to create something funny). Students can change how they work on the activity (e.g., explore interesting but nonrequired parts of readings, vary the order in which they work on parts of an assignment) or change something about the activity context (e.g., study with other people). In turn, whether and how students regulate their interest experiences can influence their motivation to reach their goals (e.g., students may

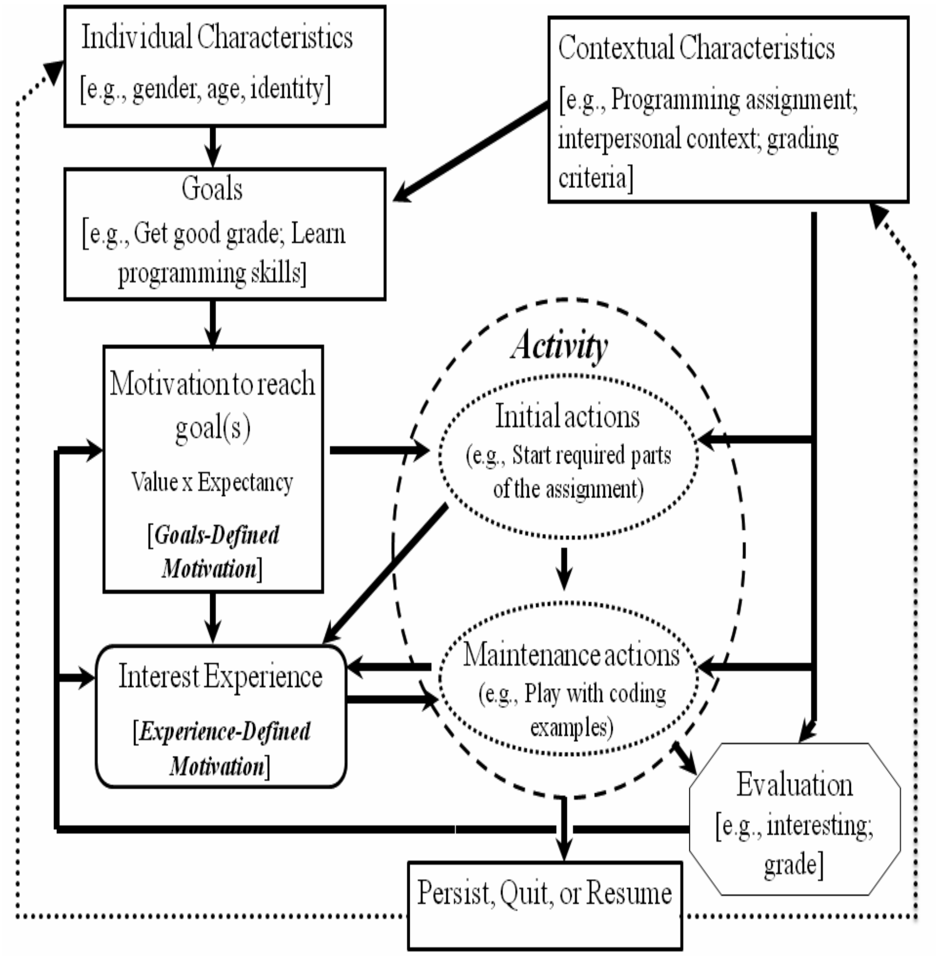

Figure 1. Self-Regulation of Motivation model (adapted from Sansone & Smith, 2000; Sansone & Thoman, 2005). The left-hand side of the figure illustrates the part of the process that occurs within the individual; the right-hand side of the figure illustrates the role of the context at various points in the process. In the middle lies the "activity," which is composed of the actions resulting from the transaction among individuals' goals, task characteristics, and the context in which the person performs the activity at a particular point in time. For simplicity's sake, we have illustrated a "snapshot" of this process at a particular point in time. Over time, however, we expect that the process influences subsequent development of a person and his or her context (dashed lines).

value the achievement outcome more if the experience becomes more interesting; Eccles & Wigfield, 2002).

Thus, the "activity" is constructed by each student, with his or her actions directed and energized by motivation to reach goals and by motivation to experience interest while working toward those goals. As illustrated in the figure, these actions are also shaped and constrained by characteristics of the task and the context. Thus, this framework suggests that to understand students' motivation to select and persist in STEM fields, it is important to understand how two kinds of motivation (goals-defined and experience defined) may operate within the process of self-regulation as students engage in STEM-related activities.

Figure 1 illustrates a snapshot of this hypothesized process at one point in time. Although "individual characteristics" and "contextual characteristics" are illustrated at the beginning point of the process, over time we would expect this self-regulatory process to in turn influence characteristics of both the person and the context (dashed lines in the figure). That is, over time the process contributes to the person's individual development (e.g., development of individual interests, identity, self-efficacy) and to the selection and construction of contexts in which the person lives (Renninger, Sansone, & Smith, 2004; Sansone, Thoman, & Smith, 2010). For example, Lucia's enjoyment in creating a logo for her own Web page might feed back to thinking about herself as a "computer person," and to choosing to take more classes in the field. Alternatively, receiving a poorer grade on the assignment might lead her instead to consider herself as not a "computer person," and to take classes in fields other than computer programming. Over time, then, her initial experience can shape whether she gains further knowledge in a field, learns to use and connect what she learns, and so on—that is, whether her initial interest experience develops into an ongoing individual interest (Hidi & Renninger, 2006).

It is important to note that this process is not limited to earlier stages of interest development, however (Hidi & Renninger, 2006). That is, although the need to regulate the interest experience may be greater at initial stages, when individuals first encounter a task or domain, the model suggests that regulating interest can be integral to maintaining motivation at all stages of interest development. For example, even if Lucia develops an individual interest in computer programming, she might not find every task related to her individual interest to be interesting, or she might need to maintain motivation past the point at which she finds the task interesting in order to complete it.

Evidence for the Integration of Interest in Self-Regulation

Considering the interest experience as embedded within self-regulation suggests several important implications illustrated in the opening example. First, it suggests that we must consider how the process of goal striving, not just goal content, can affect the experience of interest. For example, Emily and Lucia might experience different interest while working on the assignment not only because they began with different goals, but also because of the experience created by working toward those goals under the conditions created by the task and the instructor. Second, if the experience of interest is critical to maintaining motivation over time, we should see evidence of purposeful regulation of interest when students are trying to maintain motivation to reach their goals. For example, we would expect Lucia to be more likely to do the things that made working on the assignment more interesting, such as playing around with the examples, the more motivated she is to reach her goal of learning programming skills. Furthermore, we would expect that because it may take extra effort and time to make the experience more interesting, it is possible for these efforts to sometimes conflict with completing a task in the quickest or most straightforward way. For example, because Lucia spent more time exploring the examples and trying to create her own logo, she ran out of time to work on the assignment. We next review some of empirical research that addresses these implications.

The Process of Goal Striving and the Experience of Interest

Goals direct individuals' orientations toward activity. The experience of interest can potentially occur with a variety of goals, and is not necessarily limited to particular goal content. The key to a particular goal's effect is whether it is associated with performing the activity in a way that is involving and interesting for the person. Although that experience may be more likely with certain goals (e.g., when goals are freely chosen, are defined in terms of achieving good performance outcomes rather than avoiding bad performance outcomes, and satisfy basic psychological needs; Deci & Ryan, 2000; Elliot & Sheldon, 1997; LaGuardia, 2009), goal content itself does not automatically confer or block the experience of interest. For example, performance achievement goals defined in terms of avoiding failure tend to be associated with lower interest (Elliot & Church, 1997). However, Smith, Sansone, and White (2007) found that in the context of salient gender-based stereotypes about math ability, women lower in achievement motivation who held avoidance goals experienced greater interest when performing a computer science activity.

As illustrated in the figure, the degree to which someone is motivated to reach his or her goals is one determinant of his or her experience. Research has found that this motivation, derived both from value and expectancy of reaching goals, can directly contribute to the experience of interest (Eccles & Wigfield, 2002; Harackiewicz & Hulleman, 2010; Harackiewicz & Sansone, 1991). For example, early research concentrated on the role of self-efficacy and perceptions of competence as predictors of whether students find working on a task to be interesting (Bandura, 1982; Deci & Ryan, 2000; Harackiewicz, 1979; Sansone, 1986; White, 1959). These perceptions are essential to students' expectations for being able to attain an achievement goal (Pintrich, 2000; Schunk, 1991). More recent research has focused on interventions that increase the value of learning as a way to increase students' interest and their likelihood of taking additional classes (e.g., Hulleman, Durik, Schweigert, & Harackiewicz, 2008), rather than focusing exclusively on factors that enhance expectations.

For example, Hulleman and Harackiewicz (2009) found that an intervention that encouraged high school students to make connections between what they were learning in science and their own lives was associated with students' reporting greater interest, and receiving higher grades, particularly for students who began with lower expectations for performance. Thus, enhancing the perceived utility value of learning the science material (i.e., where value derives from the belief that the content of what is being learned can be useful in the person's own life) was associated with greater interest while learning, for those whose motivation was lower because of lower performance expectations. This interest, in turn, predicted greater interest in learning more in the future. The boost from adding utility value can also occur through parental interventions, such as when parents are provided training in how to converse with their children about the utility value of STEM (Harackiewicz, Rozek, Hulleman, & Hyde, 2012). Thus, over and above effects for goal content, research indicates that the expectancy and value of reaching goals (i.e., goals-defined motivation) can directly affect interest.

A second way the process of goal striving can affect interest results from whether there is congruence between goals or between goals and the context. If students approach an activity with multiple goals that are not congruent with one another, or if goal-relevant actions are constrained or discouraged by the environment, interest may be reduced. For example, in Sansone, Sachau, and Weir (1989), college students worked on a computer game and then received instructional feedback on how to score more points. This instructional feedback was associated with lower interest when students were led to adopt an initial goal to explore the fantasy adventure (i.e., a goal that was not defined in terms of their competence at the game). The same instructional feedback was associated with higher interest when the initial goal was to acquire skill at the game. In this case, the game itself and the instructions received were identical across all students, so students experienced interest at different rates because of matches between their initial goals and instructional feedback, not because of the task itself or the content of the instructions (e.g., Sansone et al., 1989).

Rather than focusing on the presence or absence of competence-related goals, research by Harackiewicz, Barron, Elliot, and colleagues has examined goal congruence among different kinds of achievement goals (performance and mastery goals), and as moderated by individual differences in achievement orientation (Barron & Harackiewicz, 2001; Elliot & Harackiewicz, 1994; Harackiewicz & Elliot, 1993, 1998). In contrast to research suggesting that mastery goals are associated with intrinsic motivation and that performance goals are associated with extrinsic motivation, they found that congruence among achievement goals and the context was a more important predictor of interest in the activity than the type of achievement goal.

Recent research by Shechter, Durik, Miyamoto, and Harackiewicz (2011) showed that information that emphasized the usefulness of learning a new math technique (i.e., added utility value information) had different effects on students' interest as a function of students' cultural backgrounds and whether the usefulness was framed in terms of distal (e.g., graduate school) or proximal (e.g., shopping) outcomes. The distally framed utility value information was associated with greater interest primarily for students from Asian backgrounds, which was hypothesized to be more congruent with their characteristic greater focus on distal outcomes, relative to students from Western backgrounds (e.g., Maddux & Yuki, 2006). Thus, in addition to congruence between goals and the context being important to whether students experience interest, Shechter et al.'s findings suggest that the importance of congruence extends to interventions to enhance the degree to which students' value attaining these goals. Freitas and Higgins (2002) further showed that individuals enjoy tasks more when there is congruence between individuals' regulatory focus during self-regulation (i.e., whether individuals' self-guides during self-regulation reflect "ideals" [accomplishment] or "oughts" [duty or responsibility]) and the nature of their actions (e.g., whether oriented toward finding correct solutions or toward avoiding errors).

The lack of congruence at multiple points in the process may thus be a factor in how students who begin STEM-related activities come to experience lower interest. That is, if students have goals that do not match with the context or the kinds of instruction and feedback they receive, or with the ways in which they self-regulate, they may come to experience lower interest while engaged in these activities. In our example, Emily and Lucia could experience different levels of interest because the orientations toward the assignment created by their goals might be differentially supported by the structure of the class.

Purposeful Regulation of the Interest Experience

When students find an activity interesting, they will persist without any seeming effort, and sometimes in the face of prohibitions (e.g., watching streaming videos). When students do not have enough interest to motivate work on an academic activity, in contrast, the easiest and readily available response is to quit (or never start). This is the behavior Larry displayed in our opening example, clearly showing a need to regulate his motivation for the assignment. Most research acknowledging the importance of self-regulation of motivation (e.g., Boekaerts, 1996; Pintrich, 2000; Wolters, 2003) has tended to focus on how students can ensure that their motivation to reach a particular goal may be maintained, such as through strategies that include goal-oriented "self-talk" (e.g., enhancing importance of the goal), bolstering efficacy beliefs, and so on. Rather than quitting when the experience is not interesting, therefore, research suggests that individuals can use strategies that strengthen the motivation to reach the goals (e.g., remind oneself about the importance of achievement outcomes). As just described, however, one consequence of these strategies is that they can also directly affect students' experiences, and in positive or negative ways. For example, students can become more engaged and involved as a result of valuing the learning outcome more (i.e., experience greater interest), or they may become more distracted as a result of greater worry about failure (i.e., experience lower interest).

In addition to these potential direct effects, however, research has also found that the degree of goals-defined motivation can affect the experience indirectly, by motivating students to regulate interest (Sansone, Weir, Harpster, & Morgan, 1992). Sansone et al. conducted several experimental studies that provided initial evidence for students' active and strategic regulation of the interest experience. For example, individuals assigned to perform a repetitive copying task engaged in interest-enhancing actions primarily when given a good reason to value the task (i.e., when told that there were health benefits). Use of these interest-enhancing strategies (e.g., varying how they copied the letters or reading incidental text about the history of the displayed type font) was associated with greater likelihood of performing the copying activity again in the future. Furthermore, use of these strategies became incorporated into how individuals defined the activity (e.g., students were more likely to define the task as involving the opportunity to learn about different kinds of lettering) (Sansone et al., 1992). Thus, without any instruction or direction by the experimenters, when provided a reason to value the task, individuals systematically changed the activity into something more interesting to perform.

However, the use of these interest-enhancing strategies was also associated with fewer letters being copied (i.e., lower performance) during the time period allowed. These patterns were later replicated in a series of three studies reported by Smith, Wagaman, and Handley (2009). One potential (though perhaps unintended) consequence of regulating the interest experience is that actions that make the experience more interesting can also interfere with or delay reaching goals.

Potential Trade-Offs Between Regulating Interest and Goal-Related Performance

In addressing the possibility of unintended consequences, Sansone, Wiebe, and Morgan (1999) proposed that the nature of the consequences might depend on the time frame over which the activity occurs. In their study, rather than having a set time period in which to copy the letters, individuals were told to copy letters for as long as they needed to be able to evaluate the task. Similar to the findings of Sansone et al. (1992) and Smith et al. (2009), when given a reason to value the task (in this case, helping others), individuals were more likely to vary how they copied the letters. In Sansone et al.'s (1999) study, however, the use of this strategy was associated with more letters being copied, because without a time constraint, individuals persisted longer on the task. Together, these studies using repetitive tasks suggest that there may be trade-offs between regulating interest and performance on tasks in the short term, which are offset in the longer term.

More generally, an important parameter in determining the presence of trade-offs might be whether students use strategies to regulate interest that are compatible with how performance is evaluated (Lepper & Henderlong, 2000). For example, with the copying task used by Sansone et al. (1992) and Smith et al. (2009), the available strategies to regulate interest (varying how they copied and reading incidental text) were incompatible with copying as many letters as possible in a short, timed period. Nevertheless, some individuals chose to do them anyway.

However, it is possible that these trade-offs emerged only because students saw this as a short-term, novel activity in which achievement was not of concern. We thus examined whether these trade-offs could emerge when the activity instead involved achievement outcomes, focusing on the specific context of online learning. When learning takes place "online" via the Internet, students are primarily responsible for regulating their own patterns of engagement with learning activities (Allen & Seaman, 2007; Artino & Stephens, 2009). As a result, relative to traditional classrooms, online learning can allow the construction of individualized learning contexts. However, online learning also can be associated with greater challenges to self-regulation (e.g., by not providing structure for effective time management or by providing easy access to temptations), allowing for trade-offs to more easily appear. For example, Sansone, Smith, Thoman, and MacNamara (2012) found that undergraduates in an online section of an upper-division psychology course were more likely than students in the on-campus section to report trying to make studying for an exam more enjoyable by exploring material on the class Web page. The more students in the online section reported using this strategy, however, the greater their interest but the poorer their exam performance.

Although suggestive, the results of Sansone et al.'s (2012) study were correlational in nature, and thus could not address the causal paths suggested by the theoretical framework. Thus, Sansone, Fraughton, Butner, and Zachary (2013) examined this process in the context of a controlled experimental study in which undergraduates worked through a timed (90-minute) online lesson on hypertext markup language (HTML) programming. Students were randomly assigned to receive additional information about how they could use HTML skills (utility value information added) or received no additional information, and then they worked for an hour and a half on the lesson, with their online behaviors unobtrusively recorded. The results suggested that receiving information about the utility value of learning HTML skills at the outset was associated with greater engagement with on-task but optional features of the lesson (i.e., interactive examples and exercises). These engagement behaviors predicted greater interest in the lesson and higher scores on a quiz of HTML knowledge, both measured after the timed lesson session was over. Finding the lesson interesting, in turn, predicted whether students requested the access code to the entire online computer programming class.

However, engaging in these on-task behaviors was also associated with lower scores on an assignment that had to be completed within the timed lesson session, because the more students engaged the examples and exercises, the less time they had left to work on the assignment. Moreover, although students in the utility value information conditions spent more time on task during the lesson session, they were also more likely to access some off-task websites, and accessing off-task websites also predicted greater lesson interest. Together, these results suggest that the relationship between motivation and performance may not be linear, because behaviors that make learning more interesting can be on task and off task, and can be associated with both lower and higher performance, depending on how performance is measured at a particular point in time. Thus, it may be important for educators to understand that certain behaviors or patterns of behaviors that seem ineffective or reflective of poor self-regulation may actually be in service of regulating interest.

Applications to STEM Learning

The SRM model makes general predictions about how the experience of interest is embedded in the process of self-regulation over time, highlighting the importance of understanding students' efforts to regulate motivation toward goals and their experience of interest. We have used this model to provide insights into why students may not select or persist in STEM careers, focusing particularly on the importance of the social context for interest in STEM, as well as on trade-offs related to students' attempts to regulate interest.

How the Social Context Influences the Experience of Interest in STEM

The SRM model suggests that the social context can influence students' experience of interest in a number of ways. For example, if students approach STEM activities with interpersonal goals, their interest may differ as a function of how well the activity and context are in match with those interpersonal goals. In support of this, Isaac, Sansone, and Smith (1999) found that college students higher in interpersonal orientation (who are more likely to be women) found a math-related task more interesting when they performed the activity with another "student" (actually, a confederate of the experimenter) present, regardless of whether they worked with or just alongside the person. Morgan, Isaac, and Sansone (2001) found that female undergraduates were more likely than male undergraduates to cite wanting to work with and help others as their reasons for choosing the type of work they wished to do. Both female and male students rated careers in STEM fields to be less likely to afford these interpersonal goals, and these perceptions predicted lower anticipated interestingness of these careers. Thus, (in)congruence with interpersonal goals predicted the real or anticipated interest experience of STEM-related activities, and this pattern has been replicated in more recent research (Diekman, Brown, Johnston, & Clark, 2010).

We have more recently expanded the examination of the role of the social context to include how feedback from others might influence students' evaluation of their experience. For example, Thoman, Sansone, Fraughton, and Pasupathi (2012) found that undergraduates' perceptions of how interesting they found a college physics class differed as a function of whether peers seemed to be listening when students talked about topics from the class. These effects were obtained even though the reported conversations took place outside of class, after the topics had been covered. Moreover, the effects of peer responsiveness were unchanged when controlling for the perceived degree to which peers agreed with their views of the topics. These results suggest that others' reactions when students attempt to talk about a novel topic that they might have found interesting can be an important mechanism influencing whether initial experiences are likely to develop into further attempts to learn more about the topic. On the basis of these findings, we would expect in our opening example that the e-mail exchange Lucia had with a friend to share logo ideas would facilitate sustained interest in computer programming because her friend was responsive.

However, the degree to which others appear responsive may also be an avenue through which individuals who are underrepresented in STEM fields receive feedback that leads to relatively negative evaluations of the experience. For example, peers (or teachers) in STEM classes may be less likely to listen to students who come from backgrounds that are different in terms of gender, ethnicity, culture, language, and so on. As a result, their initial interest may be less likely to be developed or maintained, contributing to their continued underrepresentation in STEM fields (see also Thoman, Smith, Brown, Chase, & Lee, 2013).

We have also recently begun to examine the role of the social context in terms of how students' senses of belonging (i.e., the extent to which they feel as if they "fit in") predicts their interest experiences. We focus in particular on this relationship in the context of students' alternative choices and relative experiences across domains. In this work, we examine students' concurrent interest and sense of belonging in both STEM and non-STEM classes. Most research takes a within-domain perspective on interest (i.e., how experiences in STEM affect STEM interest); however, students typically take classes across several domains in one academic term and therefore compare (implicitly and/or explicitly) their experiences across domains. For example, Thoman, Arizaga, Smith, Story, and Soncuya (2014) recruited a sample of college female STEM majors concurrently taking both a STEM and a humanities or liberal arts (H/LA) class. They found that not only does lower sense of belonging in STEM predict lower experience of STEM interest, but also, for some women, greater belonging in H/LA classes predicts lower experience of interest in STEM, even when controlling for STEM belonging. Thus, not only can concerns about the social context in STEM make students feel pushed out of the domain, but experiencing a more positive social context elsewhere can pull some students away from STEM. This study illustrates how examining interest within a multiple (potentially competing) domains framework can generate findings otherwise absent in single-domain designs. Such work fits well with recent theories of student interest and identity development that emphasize students' management of multiple motivational experiences (Hofer, 2010; McCaslin, 2009), as well as with data suggesting that students switched out of STEM majors both because of lower interest in STEM and greater interest in other majors (Renninger & Schofield, 2012; Seymour & Hewitt, 1997).

Trade-Offs When Regulating Interest in STEM

The research indicating the possibility of trade-offs when students regulate interest is also an important avenue to consider in attempting to understand the relationship between the interest experience and persistence in STEM. As noted, certain behaviors or patterns of behaviors that seem ineffective or as reflecting poor self-regulation may actually be in the service of regulating interest. Traditional introductory college classes in STEM are very structured, discouraging the kinds of behaviors that might be essential for maintaining interest. For example, in the online HTML programming lessons used by Sansone et al. (2012), it would be easy (and more typical) to construct the lessons to discourage students from spending time playing around with the examples at the cost of time to work on the assignment. However, these data also suggest that by discouraging those behaviors, we would also be constructing the lessons in ways that lowered students' interest and their subsequent likelihood of learning more on their own. Thus, what begins as a short-term trade-off can turn into a long-term one if students drop out of the field, and this may become more critical as students progress further in school.

An example of this can be seen in work by Calabrese Barton et al. (2013), who detailed case studies of two African American girls as they progressed from sixth grade to eighth grade science. Particularly striking was the case of Diane, who began with a clear interest in science activities both in and out of school, and who viewed science as "helping me to learn new things" (p. 39). At the beginning of seventh grade, she won an award for building the rocket that flew the farthest. She was heavily engaged when working on science projects, going slowly through the assignments, exploring different features beyond what was required, and, as a result, often was the last one to turn them in. Her teacher enjoyed her in class but did not consider her a top student (the "top students" were the ones who finished assignments earlier than everyone else). The researchers noted that as the science curriculum became "tightened" in eighth grade (i.e., valuing "expediency and getting it right over slower, more purposeful efforts to think about the science at hand" [p. 64]), Diane's work was "valued for being right rather than being interesting and thought-provoking" (p. 65). By the end of eighth grade, Diane viewed herself as not good in science, and her interest and engagement in science in and out of the classroom had decreased. As applied to our opening example, Lucia may receive a lower grade on the assignment because of the added time she spent actively engaged with other materials. If she (or the instructor) interprets her assignment grade as indicating that she was not good at programming, Lucia may move away from pursuing knowledge in this topic (and perhaps the field).

In addition, the ways someone might choose to make the learning experience more interesting (e.g., relying on the social context) may be less likely to be supported in traditional STEM learning environments, putting some people at a disadvantage (e.g., women, people from collectivist cultures). For example, in Isaac et al.'s (1999) study, students higher in interpersonal orientation were more likely than individuals lower in interpersonal orientation to elicit off-task conversation from the confederate who was ostensibly working on the math activity with or alongside the student. For individuals higher in interpersonal orientation, greater off-task conversation was positively correlated with their interest and unrelated to their math performance. For individuals lower in interpersonal orientation, in contrast, the off-task conversation was unrelated to their interest in the math activity but was negatively correlated with their math performance. These findings illustrate that if the situation were structured so as to limit or penalize off-task conversation, this would benefit students lower in interpersonal orientation in terms of their performance, but make the experience less interesting for individuals higher in interpersonal orientation.

In addition to emphasizing how STEM instructors might create activities to minimize trade-offs, it may also be important to consider whether STEM students perceive greater restrictions (whether real or imagined) on their interest-enhancing options when the curricula implicitly suggest that interest and enjoyment are no longer critical to learning STEM at advanced levels. That is, even if teachers are aware of and open to students' potential motivation regulation efforts, if the broader cultural message about STEM learning implies that students should be able to persist without changing learning activities, students might think it is improper to change STEM activities or contexts in ways that enhance interest. Perhaps even worse, students might feel that needing or wanting to regulate their interest is a sign that they "don't have what it takes" to be a scientist. For example, Shanahan and Nieswandt (2011) examined high school (Grade 10) students' expectations and perceptions of the science student role. On the basis of students' responses, they identified five expectation themes, indicating that science students were expected to be creative, intelligent, skilled in science, well behaved, and scientific. Tellingly, "be interested in math" was one item constituting the "intelligence" factor, and "enjoy trial and error experimenting" was one of the items constituting the "skilled in science" factor. Tracey (2002) also found strong associations between students' ratings of vocational interests and competence in those domains or dimensions, and Nauta, Kahn, and Angell (2002) found reciprocal relations between college students' self-efficacy and career interests over a year's time. Thus, messages conveyed to both teachers and students about the self-regulation of interest being a normative part of sustained motivation in STEM have important implications for students' choices and identities as future scientists.

Potential Future Directions

Given our perspective, which focuses on how individuals might create and maintain motivation, we are interested in expanding our questions to include how these self-regulatory mechanisms might explain whether initial interest experiences develop into individual interests, and whether the same contextual features influence the self-regulatory process differently depending on age and stage of interest development. Our empirical work has tended to examine undergraduate students at points at which they have initial contact with STEM-related activities, and the findings might differ if we examined them at later points in time. It is possible, for example, that peer responsiveness when talking about interesting topics is particularly critical in the shift from situational interest to sustained interest, but is less critical if one has a well-established individual interest. Alternatively, it may be that individuals with well-developed individual interest are able to maintain this interest because they have selected into groups that also find the topics interesting, thus ensuring that peers are likely to be responsive. This may be more of a challenge for individuals who come to STEM fields from underrepresented backgrounds (Thoman et al., 2013). For example, in the case study of Diane mentioned previously (Calabrese Barton et al., 2013), the teacher interpreted Diane's dropping out of the science lunch club as an indicator of Diane's lack of interest in science. However, Diane dropped out after the other African American students in the club had dropped out, and Diane saw lunch time as the opportunity to meet with her friends who were not members of the club.

In addition, our work highlights the importance for motivational interventions to include an understanding of students' individualized constructions of activities. For example, external attempts to add value or interest for individuals with well-developed interest may actually backfire, because a specific externally added feature might not be compatible with their individualized constructions of the interest-related activities (Sansone, Fraughton, Zachary, Butner, & Heiner, 2011). Moreover, students may differ in the extent to which they see activities required as part of class curricula as representative of and useful for the vocation (e.g., Husman, Lynch, Hilpert, & Duggan, 2007). As a result, they may also differ in whether and how they regulate interest for the class activities, and they may be differentially motivated to regulate interest by interventions framed in terms of proximal or distal utility value (Shechter et al., 2011). Thus, the most effective intervention strategies may need to consider students' individualized views of the present activities and their perceived relationships to the activities that would be involved when actually working in that field.

Furthermore, as we have noted elsewhere (e.g., Sansone et al., 2010), although we have talked about the self-regulation process using language that suggests conscious awareness, as with other self-regulatory processes, this does not mean that individuals necessarily articulate each step in the process prior to acting. For example, Bargh and Chartrand (1999) outlined the process of "automatic" self-regulation, such that over time. goals and goal striving can be activated implicitly in repeated situations, and individuals might not be consciously aware of the different steps in the process (unless something forces them to be aware). In this case, behaviors might still be purposeful with regard to regulating interest, but students might not explicitly perceive or describe them in that way to themselves or others. In addition, behaviors that began as strategies to promote motivation may come to be routinely performed in similar situations, such that they become habits rather than strategies (Ouellette & Wood, 1998). In this case, the behaviors are no longer purposeful with regard to regulating interest. For example, individuals who are more interpersonally oriented may initially choose to work with other people to make an activity experience more interesting, and then over time come to make working with others a routine part of doing the activity without consideration of motivational impact.

Even if these behaviors are no longer intentional, however, they may still affect motivation. One implication then is that without being aware of it, individuals' actions could continue to promote or detract from goals-defined and experience-defined motivation. For example, individuals who initially chose to work with others on an activity because it made it more interesting might continue to work with others even when the interactions no longer promote interest (e.g., when the interactions have become stressful). In this case, unless individuals become aware that their habitual ways of performing the activity are not required, they may start to avoid the activity, quit early, and so on. When students are regularly engaged in activities related to well-developed interests, therefore, it is possible that the process of regulating motivation might become more automatic, and the strategies incorporated into how they define the activities. However, these activities might also be more vulnerable to "orphan" habitual behaviors that no longer serve a positive motivational function. These possibilities suggest that when activities related to well-developed interests begin to pale, students might benefit from conscious, mindful attention to how they perform them (Shapiro & Schwartz, 2000), and consider changes.

Concluding Thoughts

One way to interpret the different profiles displayed by the three students in our opening example is to see them as reflecting stable individual differences in interest. So, Lucia, but not Larry or Emily, has an interest in computer programming. Alternatively, we may consider interest as a luxury when learning science, math, technology, and engineering, something to wish for but not necessary for learning and self-regulation. From this perspective, Emily is the model student despite her lack of interest in the content of the assignment. We have suggested instead that the experience of interest serves as an integral part of self-regulation over time, and that it is an essential part of maintaining motivation to learn. From this perspective, "intrinsic" and "extrinsic" motivation are not necessarily opposing forces, but can work together over time. Our perspective also highlights that motivation results from what we are experiencing while working toward goals, not just from the goals themselves. Whether and how we respond to the need to experience interest while we learn are important questions—and the answers are not independent of the motivation that led us to begin the activity in the first place.

What are the implications for educators, parents, and students themselves? One implication is that we must recognize that some short-term trade-offs between interest regulation and performance might occur. Our work has involved primarily college students in the United States, and the voluntary nature of higher education makes self-regulatory processes particularly important. However, work by others, some of which we have described in this chapter, suggests that these potential trade-offs can emerge for younger students (e.g., middle-schoolers) as well.

One clear implication is that student behaviors may be mischaracterized as off-task or unfocused when they are beneficial for long-term motivation. "Off-task" behaviors (e.g., designing a logo) might actually be on-task for students, depending on how they define the activity (e.g., creating a better web page). Not all off-task behaviors are beneficial or in service of regulating motivation, of course. Defining where the line is can be challenging.

One step that educators could take is to conceptualize learning activities not only in terms of learning objectives or whether the activities are inherently interesting, but also in terms of potential pathways through which students might make the activity interesting for them. Simply allowing for variety and flexibility within learning objectives could be sufficient to support interest regulation, and when integrated as part of the expected learning process, might lead to fewer trade-offs. Thoughtfully scaffolding opportunities for variety and flexibility when designing a learning activity may also help clarify the line between on- and off-task behaviors. We recognize that the implications of our work do not match contemporary policy pushes for standardized material, time frames, and testing. Moreover, it may not be necessary to promote motivation over the long term for all students in all subjects. When the aim is to promote perseverance in a field, however, our work suggests that it would be counterproductive and short-sighted to neglect the process by which students regulate motivation.

One important point that we do not yet know is whether, to be effective, the process of interest regulation has to happen organically (with educators creating conditions that support the process) or whether it is possible to teach others to regulate interest as a way to maintain motivation. For example, if we told Emily to design a logo for a website (Lucia's actions), would it work to create more interest in programming for Emily? Or, because the idea of designing a logo did not come from Emily, would the assignment have no effect, or even a negative effect, on Emily's motivation? What if, instead, an intervention were directed at educating students generally about the importance of regulating interest, but encouraging them to identify for themselves the strategies of most relevance? Our research thus far does not provide specific suggestions for interventions in the process.

However, our research does suggest that it is important to recognize and support interest regulation as it arises from the student. From this perspective, Larry, Emily, and Lucia are not necessarily students who differ in their motivation for STEM; rather, they are at different points in the regulation process. Whether they will continue to learn computer programming depends on what happens next.

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