The Variable Relationship Between On-Task Behavior and Learning

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Abstract

The *Time-on-Task hypothesis* asserts that learning is a function of time one allocates to a learning task. Thus, time off-task reduces learning opportunities and is therefore thought to be detrimental to learning. To date, the available research suggests a positive relationship between time on-task and achievement; however, the strength of the correlation fluctuates dramatically. One potential explanation that has been put forth to account for the mixed results is differences in the operational definition of *time*. The present study tests this hypothesis by examining whether a more stable relationship between on-task behavior and learning can be obtained if *time* is operationalized in a uniform way. The results of the present study indicate that while on-task behavior was positively correlated with learning outcomes overall, marked variability was still found across classrooms suggesting that the divergent results obtained in previous research are not driven solely by differences in how *time* is measured.

Keywords: On-task behavior; Attention; Learning; Achievement

Introduction

In education a common assumption is that the more time children attend to something, the better they should learn the material. This tenant of conventional wisdom was formalized by Carroll (1963) and has become known as the *Time-on-Task hypothesis*. The *Time-on-Task hypothesis* asserts that learning is a function of the amount of time one allocates to a particular learning task. Thus, time off-task reduces learning opportunities and is therefore thought to be detrimental to learning (Carroll, 1963). Carroll's *Time-on-Task hypothesis* spurred a great deal of research attempting to show that learning is directly related to the amount of time one spends on a particular task (Cobb, 1972; Lahaderne, 1968; McKinney, Mason, Perkerson, & Clifford, 1975; Samuels & Turnure, 1974; Frederick, Walberg, & Rasher, 1979).

Given that predictors of achievement are often intractable (see Karweit & Slavin, 1980 for discussion), identifying factors that are malleable is of particular importance for practitioners. Thus, *time* is a factor that is of great interest as it is largely a malleable factor. If time is shown to be a meaningful determinant of learning, then interventions can be created that increase time or that optimize how existing instructional time is utilized.

Despite considerable work in this area, the understanding of the relationship between *time* and learning remains limited, as the existing literature has yielded conflicting results. To date, the available research suggests a generally positive relationship between the amount of time spent on-task and achievement. However, the strength of the correlations fluctuate widely, ranging between 0.10 and 0.70 (Karweit, 1984; for more recent examination of the relationship between on-task behavior and learning see: Baker, Corbett, Koedinger, & Wagner, 2004; Fisher, Godwin, & Seltman, 2014; Gobel, 2008; Godwin & Fisher, 2014; Kovanovic et al., 2015).

While a full account of the factors driving the variability in the relationship between time and learning is needed, some potential explanations have been put forth in the literature. One possible explanation for the mixed findings is the variety of ways in which *time* has been operationalized. Indeed, Karweit and Slavin (1982) suggest that differences in operational definitions, as well as methodological and procedural differences, may contribute to the mixed results across the existing literature. Although establishing precise operational definitions is important for all research, it may be particularly pertinent in this context given that *time* has been defined in many different ways across a multitude of studies (for discussion see Caldwell, Huitt, & Graeber, 1982; Frederick & Walberg, 1980; Goodman, 1990; Karweit & Slavin, 1981; Wiley & Harnischfeger, 1974). For example, in the prior literature *time* has been equated with attention and thus it has been defined at the student level as looking time, on-task behavior, and engaged time (e.g., Choudhury & Gorman, 2000; Cobb, 1972; Fisher, Godwin, & Seltman, 2014; Godwin & Fisher, 2014; Lahaderne, 1968; Lee, Kelly, & Nyre, 1999). Other researchers have defined *time* at a classroom level in which *time* is indexed by the amount of time allocated, or the amount of time actually spent on an instructional activity or a particular subject area (e.g., Arlin & Roth, 1978; Baker, Fabrega, Galindo, & Mishook, 2004). Still other researchers have equated *time* with the amount of schooling and operationalized *time* as the length of the school day, length of the school year, total number of school days attended, or even years of schooling (e.g., Agrawal, Smith, & Wick, 1977; Coleman et al., 1966; Cooper, Allen, Patall, & Dent, 2010; Hough & Bryde, 1996; Hyman, Wright, & Reed, 1975; Karweit, 1973; Wiley & Harnischfeger, 1974). With such a wide variety of definitions of *time*, it is perhaps not surprising that discrepant results have been obtained.

In an influential study with elementary school students, Karweit and Slavin (1981) tested the hypothesis that the manner in which *time* is operationalized (among other factors) influences the relationship between time and learning. A small subset of children from 18 elementary school classrooms participated in the study. The sample consisted of two age groups: second/third graders and fourth/fifth graders. In this observational study, several measures of time were collected during mathematics instruction in order to assess whether time (in any form) was a significant predictor of children's achievement scores on the Mathematics Computation and Mathematics Concepts and Applications subscales of the *Comprehensive Test of Basic Skills* (CTBS). The authors focus on four central measures of *time* which include: Total scheduled time (i.e., the amount of time allocated to math instruction), Total instructional time (i.e., the amount of time actually spent on math instruction subtracting time for procedural activities), Engaged time (i.e., the amount of time students spent engaged with the instructional activity/ time-on-task), and rate of engagement (engaged time/total instructional time).

Karweit and Slavin (1981) found mixed results as a function of how *time* was measured and as a function of grade level. For second and third grade students, only engaged time and rate of engagement were found to be significant predictors of children's CTBS post-test scores. All other measures of *time* (i.e., total scheduled time and instructional time) were not significantly related to second and third grade children's CTBS scores. In contrast, for older children none of the measures of *time* (i.e., total scheduled time, total instructional time, engaged time, nor rate of engagement) were found to be significant predictors of their CTBS scores.

Karweit and Slavin (1981) concluded that measures of *time* which focus more closely on the amount of time students spend on-task or measures that are more indicative of how students utilize instructional time are stronger predictors of achievement compared to measures which operationalize *time* more generally such as time allocated for instruction or even total instructional time. Thus, the manner in which *time* is operationalized is thought to influence whether a relationship between *time* and learning is found as well as the strength of that relationship. Additionally, the authors point out that the inconsistency in the relationship between *time* and learning across grade levels has been observed in other studies and highlights the need to examine individual difference factors (e.g., interest in the subject matter, student aptitude) which will likely contribute to the amount of *time* needed to master course content.

Although the work of Karweit and Slavin (1981) suggests that using a uniform measure of *time*, and in particular using measures such as time on-task or engaged time (compared to more global measures) should reduce variability and increase the strength of the relationship between *time* and learning, this issue remains unresolved and continues to be an important area of inquiry today (see Kovanovic et al., 2015). The present study continues to explore the relationship between *time* and learning by examining whether the variability in the prior literature is merely an issue of measurement inconsistency. Specifically, we investigate whether a positive relationship between on-task behavior and learning is *consistently* obtained when utilizing a uniform measure of *time* (i.e., for all participating classrooms the fraction of students' on-task behavior was recorded) in a large sample of elementary school students. The present work makes an important contribution to the literature as it examines this question with a larger sample of elementary school children and examines possible individual characteristics (i.e., gender, grade level) and school based factors (i.e., school type: private, public charter schools) which may contribute to the observed variability in the prior literature.

Method

Participants

Twenty classrooms participated in the present study. However, one classroom was excluded from analyses for reasons discussed below. The classrooms were recruited from 7 schools which included 4 charter schools and 3 private schools. Participating schools were located in or near a medium-sized city in the Northeastern United States of America. In order to obtain a representative sample, different grade-levels were recruited. Four grade-levels participated in the present study: kindergarten, first-grade, second-grade, and fourth-grade. The distribution across the four grade-levels was as follows: 5 kindergarten classrooms, 5 first-grade classrooms, 7 second-grade classrooms, and 3 fourth-grade classrooms. Despite efforts to recruit a balanced sample, third-grade teachers did not volunteer to participate in the present study. The sample consisted of 375 children (177 males, 198 females). The average number of children observed in a single observation session was 17.6 children. The number of children observed per session ranged from 10 to 23 children. These children were also part of a larger study examining patterns of attention allocation in elementary school. The results of that study are reported elsewhere (Godwin et al., In Press).

Design & Procedure

Each classroom was observed two times in order to obtain more stable estimates of children's on-task behavior. The average delay between observation sessions was 3.05 calendar days (the delay ranged from 1 day to 7 days). Each observation session lasted approximately one-hour. All observations occurred during mathematics instruction. The average number of observations per session was 249.6 and the average number of observations per child within a session was 15.5. The classroom observations occurred between October 2012 and December 2012.

Coding Behavior Coders utilized the *Baker-Rodrigo Observation Method Protocol* (BROMP) for coding behavioral data in field settings (Ocumpaugh, Baker, & Rodrigo, 2015). Training consisted of coding videotapes and live observation sessions. In order to establish inter-rater reliability Cohen's Kappa was calculated. Values ranged from 0.79 to 0.84 which exceeds the 0.75 threshold which Fleiss (1981) refers to as "excellent" in field settings.

A round-robin coding strategy was utilized in order to reduce the tendency of observers to attend to salient instances of off-task behavior. Prior to beginning the observation session, the observation order was determined. Each observation period lasted up to 20 seconds. The first unambiguous behavior observed during the 20 second period was recorded. Then the coder would observe the next child in the rotation. This process repeated for the duration of the observation. Thus, every child was observed multiple times throughout the observation session. During observations peripheral vision was utilized in order to make it less apparent to the child that he or she was being observed. This procedure has been employed successfully in prior research to reliably code middle and high school students' behavior and affect (e.g., Ocumpaugh et al., 2012).

Coders classified children's behavior as on- or off-task using the direction of the child's eye gaze. Contextual clues, such as teacher instructions, were also considered in order to disambiguate between on- and off-task behaviors. If the child was looking at the teacher or the instructional materials they were categorized as on-task. If the child was looking elsewhere, they were categorized as off-task. For each child the fraction of children's on-task behavior was then calculated by taking the number of times each child was on-task divided by the total number of observed behaviors (i.e., on-task and off-task behaviors).

Learning Measures All of the learning measures were administered by the teachers as part of their standard practice. As a consequence of collecting genuine learning measure that are used in practice, there was variability in the types of learning measures that were administered in each classroom (an issue we return to in the Discussion Section). Learning measures included: quizzes, report cards, and/or fall and winter MAP (*Measure of Academic Progress*) scores from a computerized adaptive assessment program.

The distribution of available learning outcomes was as follows: 4 students had learning outcomes which consisted of fall and/or winter MAPs, 203 students had learning outcomes which consisted of quiz scores and fall and winter MAPs; 132 students had learning outcomes which consisted of report cards and quiz scores; and 17 students had learning outcomes which consisted of report cards. Quiz scores were excluded from analysis due to low information content. One classroom utilized letter grades for their report cards (as opposed to percentages); consequently, this classroom was dropped from the analysis. As a result, both classroom observations and learning outcomes were available for 356 students from 19 classrooms.

The learning measures were converted into Z-scores and averaged together to create the composite variable *Total Learning Outcome* for each student. The composite variable *Total Learning Outcome* was computed separately for each classroom in an attempt to correct for different grading practices across schools and classrooms. This approach obviates the need for hierarchical modeling. It is important to note that hierarchical linear models were also tested; however, the estimate of the random intercept was 0 indicating that a hierarchical approach was not necessary. This finding is expected given that Z-scores were created separately for each classroom.

Results

On-Task Behavior

Consistent with estimates reported in the prior literature (50-75%, Karweit & Slavin, 1981), children were largely on-task. On average .75 (SD = .13) of children's behaviors were categorized as on-task. The fraction of children's on-task behavior ranged widely with some children exhibiting minimal rates of on-task behavior while other children were consistently on-task (fraction of on-task behaviors ranged from: .27 to 1.0).

Learning Outcomes

Recall that children's learning scores (report cards and MAP scores) were converted into Z-scores and averaged together to create the composite variable *Total Learning Outcome* for each student. This procedure was repeated for each classroom. Learning Z-scores ranged from -2.82 to 2.03.

Effect of On-Task Behavior on Learning Outcomes

Linear models were fit to assess whether students with a greater fraction of on-task behavior tended to perform better on the learning outcomes relative to their classmates. *Total Learning Outcome* was entered as the dependent variable. Four predictors were included in the model: fraction of on-task behavior, gender, school type (private, charter), and grade level (Kindergarten, First, Second, Fourth grades).

On-task behavior was found to be a significant predictor of children's *Total Learning Outcome,* while controlling for gender, school type, and grade level (β = 1.00, t = 2.60, p = .01). However, the relationship between on-task behavior and learning was weak (see Figure 1), with *Total Learning Outcome* increasing by 0.20 *SD* for every 20% rise in on-task behavior. Furthermore, on-task behavior only accounted for 1.8% of the variability in children's learning scores (R^2 = 0.018, p =.012).

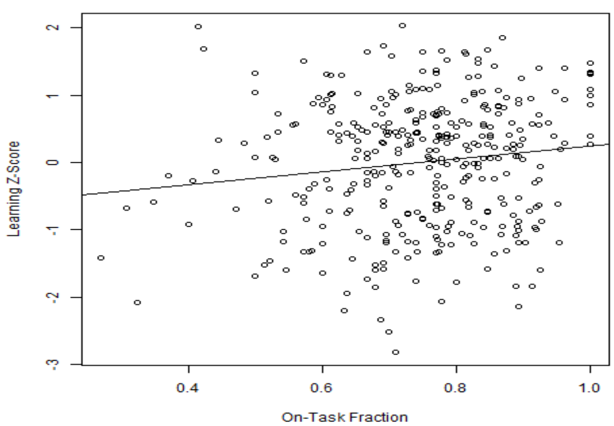

Figure 1. Scatter plot depicting the relationship between the fraction of on-task behavior and the composite variable *Total learning Outcome* (Z-score).

Moderation Analyses

Next, we examined whether the relationship between children's on-task behavior and learning was moderated by gender, grade level, and school type. The results of the moderation analyses are reported below.

Effect of Gender Prior research has found that in elementary school, females typically exhibit more on-task behavior than males (e.g., Godwin et al., In Press; Marks, 2000). Consistent with prior research, we found that females exhibited significantly higher rates of on-task behavior (M = .76, SD = .13) compared to males (M = .73, SD = .13); t(355) = 2.40, p = .017. However, the relationship between on-task behavior and *Total Learning Outcome* scores was not moderated by gender (t(352) = .90, p = .367).

Effect of Grade In order to examine whether the relationship between on-task behavior and learning varied as a function of grade-level, a moderation analysis was performed. The relationship between on-task behavior and children's *Total learning Outcome* score was moderated by grade-level, although the effect was marginally significant (F(3, 348) = 2.25, p = .08). The relationship between fraction of on-task behavior and learning was smaller among first graders (β = -1.41) than it was for kindergartners (β = 1.87, p =.014), second graders (β = 1.11, p = .033), or fourth graders (β = 1.29, p = .036) [all p-values are for slope differences compared to first grade]. In future research it will be important to test the generalizability of this finding by sampling a larger number of classrooms per grade-level from a larger sample of schools in order to determine if the observed grade-level effects are consistent across samples.

Effect of School Type Lastly, a moderation analysis was conducted to investigate whether the relationship between on-task behavior and learning varied as a function of the type of school children attended (i.e., private school or public charter school). The results mirrored those of gender; the relationship between on-task behavior and *Total Learning Outcome* scores was not moderated by school type (t(352) = -1.32, p = .19).

Effect of Classroom Despite measuring *time* in the same manner across each classroom (i.e., for all classrooms in the present study, *time* was operationalized as the fraction of on-task behaviors), only a weak relationship between on-task behavior and learning was found (r = .13). Additionally, there was considerable variability across classrooms (see Figure 2). Indeed the slope estimates obtained when modeling the relationship between on-task behavior and learning were positive for 11 classrooms, while eight classrooms had negative slope estimates (see Figure 2). Furthermore, only three of the 19 classrooms had slope estimates that reached significance: a kindergarten classroom, second grade classroom, and a fourth grade classroom ($ps \leq .025$). All three of the classrooms were from charter schools. It is important to note that for all three classrooms, the direction of the effect is positive (kindergarten class β = 4.54, second grade class β = 2.46, fourth grade class β = 3.51); thus, higher rates of on-task behavior were associated with better learning outcomes. After correcting for multiple comparisons using the Bonferroni correction, the relationship between fraction of on-task behavior and *Total Learning* remained significant for one classroom, the kindergarten classroom (p = .0013).

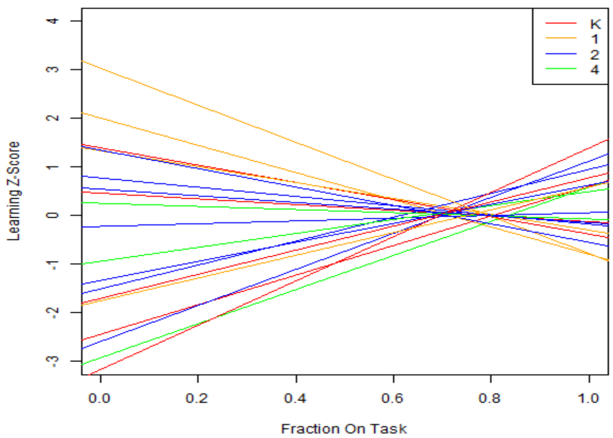

Figure 2. Displays the regression estimates for the relationship between the fraction of on-task behavior and *Total Learning Outcome* Z-scores for each classroom (each line represents a classroom).

The considerable variability observed across classrooms in the strength and the direction of the effect between on-task behavior and learning points to the possibility that the relationship between *time* and learning may be determined in part by classroom level factors. Teacher effectiveness may be one such factor. For example, high levels of on-task behavior and high learning outcomes might be indicative of classrooms with very experienced or high quality teachers, whereas high levels of on-task behavior but low learning may reflect lower quality instruction in which teachers might be engaging, but perhaps not very effective. Additionally, the composition of students within a classroom might influence the relationship between *time* and learning. For example, students who are struggling academically may need to spend large quantities of time on-task in order to obtain average learning scores whereas their high achieving peers might be able to excel academically even with minimal amounts of time spent on-task. To the extent that certain classrooms might have differing compositions of low and high achieving students one might expect that the relationship between on-task behavior and learning may be muted or even negative (for discussion see Frederick & Walberg, 1980).

Discussion

In the present study the variability in the strength of the relationship between on-task behavior and learning as well as the direction of the effect suggest that the divergent results obtained in the previous literature are not driven solely by differences in how *time* is measured. Instead, it appears that differences in the observed relationship between on-task behavior and learning may arise from other factors at the classroom level (e.g., teacher quality, years of experience, classroom size, etc.) as well as from other pertinent individual differences factors (e.g., student aptitude). However these possibilities remain to be explored further in future research.

While the present study provides important insights into the nuanced relationship between on-task behavior and learning several limitations should be noted. First, the learning measures are variable across classrooms and schools. Additionally, we were able to obtain standardized learning measures for a small subset of the participating schools - gathering standardized learning measures should be a focus of future research. Due to the inherent nature of the available learning measures some of the learning measures are more closely linked to the classroom observations (e.g., quiz scores vs. grades and MAP scores). One possibility that can be tested in future research is to assess if a stronger relationship between on-task behavior and learning can be obtained when using learning measures that are closely yoked to observations of student behavior (e.g., class assignments, unit test scores, homework grades) compared to more general measures of achievement (e.g., standardized tests). Some insights into this question have already been obtained. For example, prior research has begun to investigate this question by comparing the relationship between *time* and a subset of dependent learning measures (e.g., standardized test scores vs. chapter tests; Karweit & Slavin, 1981). Additionally, recent research has aimed to reduce potential confounds introduced by delays between observations of student behavior and the collection of students' learning outcome data by yoking observations of students' on and off-task behavior with their *immediate* learning outcomes (Godwin & Fisher, 2014). However, more systematic research is needed. Future research should also incorporate students' pre-test scores as a covariate in order to take students' level of prior knowledge into account, particularly if the lesson content is not entirely novel. As discussed previously, it is likely that students' familiarity with the material and aptitude will influence the relationship between *time* and learning. Lastly, the generalizability of the present results should be assessed by examining the relationship between *time* and learning across multiple subject areas.

In conclusion, the present work suggests that obtaining a consistent relationship between *time* and learning is likely not merely an issue of measurement and highlights the need for future work to be conducted that is able to identify the circumstances in which increasing time on-task actually results in improved learning outcomes.

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