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The effect of an in-school versus after-school delivery on students' social and motivational outcomes in a technology-based physical activity program

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Abstract

Background: Expanding opportunities to experience engaging STEM educational programs is an important pathway to increasing students' interest and competencies in STEM and, ultimately, motivation to pursue STEM careers. After-school programs offer one means to achieve this aim, but barriers such as a lack of transportation or available teachers may limit participation for some students in this context. Transitioning after-school STEM programs to in-school can provide opportunities to increase reach by removing these and other barriers. However, it is likely that this change in the learning context, from after-school to in-school, impacts student experiences and, ultimately, program efficacy by altering how students and teachers interact; as teachers and students adjust their behaviors and expectations to a more traditional learning context. To examine this potential effect, self-determination theory was used to frame how the learning context influences the social and motivational outcomes of a STEM program for underserved youth. In-school ($N = 244$; 39% girls, $M_{\text{age}} = 13$, 63% Caucasian, 18% African American, 6% Multiracial) and after-school ($N = 70$, 33% girls, $M_{\text{age}} = 12$, 55% Caucasian, 16% Multiracial, 13% Latino/a) program students completed surveys that assessed teacher-student interactions, and student psychological needs and motivation. In a structural equation model, student perceptions of teachers were entered as predictors of motivation for the program directly and mediated by psychological need satisfaction. Learning context (0 = in-school, 1 = after-school) was entered as a ubiquitous predictor.

Results: Findings support the theorized model where perceptions of teachers positively predicted psychological need satisfaction ($R^2 = .20$), and both variables positively predicted more self-determined motivation ($R^2 = .30-.35$). Findings also demonstrate an effect of learning context where learning context negatively predicted the less self-determined motivations only ($R^2 = .06-.10$) (i.e., in-school contexts are associated with less desirable motivational outcomes).

Conclusion: Findings reinforce the instrumental role of students' positive perceptions of teachers in fostering a more desirable self-determined motivation for STEM program participation. Additionally, in-school programs must consider and integrate novel approaches that mitigate the negative impact of established in-school structures and processes (e.g., grades and mandatory participation) on student motivation for these programs and, potentially, interest in STEM careers.

Keywords: Adolescence, Students, Motivation, STEM, Self-determination theory

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Science, technology, engineering and math (STEM) education is a priority for the US government in order to develop a workforce poised to fill in-demand STEM careers (National Research Council, 2015). However, shrinking school budgets and increasing testing directives have made it difficult to add new STEM education opportunities, resources, curricula, and facilities to the school day (Anderson, 2012; Leachman, Masterson, & Figueroa, 2017). In the USA, universities, non-profits and others, largely funded by government agencies (e.g., Department of Education and National Science Foundation) or corporate philanthropy (through direct giving or through a corporate-aligned philanthropy or not-for-profit), have sought to fill this gap by creating innovative after-school programs that provide quality and engaging STEM learning experiences (see Afterschool Alliance (2012) for more information on funders of after school STEM programs in the USA). These programs emphasize both conceptual learning and psychosocial dispositions that foster competence and interest in science to increase the likelihood that students can successfully pursue a career in science (National Research Council, 2015). These programs also often draw from the positive youth development (Ford & Lerner, 1992) perspective where the focus is not only on building STEM knowledge and skills, but also creating learning contexts that foster other developmental assets such as socioemotional development, critical thinking, and life skills (Allen et al., 2019).

Short-term evaluations of these programs indicate they are successful at increasing student interest in STEM learning and careers (Chittum, Jones, Akalin, & Schram, 2017; National Research Council, 2015; Young, Ortiz, & Young, 2017). However, there are significant enrollment biases for after-school programs that can hamper the ability of programs to reach students who do not already have a strong interest in STEM or lack the resources to participate in after-school programs (e.g., transportation, and competing family responsibilities and after-school activities) (Betancur, Votrub-Drzal, & Schunn, 2018; Vallett, Lamb, & Annetta, 2018). One potential solution to this problem is to leverage the high-quality curricula and programs already in use as after-school programs and integrate them into the school day. Not only could this shift improve reach, it would also provide an opportunity to insert positive youth development program values (e.g., life learning beyond the curriculum content) into school day STEM learning (Allen et al., 2019). What is unknown is how this change of context—from after-school to in-school—may modify the learning climate for students, and, ultimately, impact established program outcomes. Researchers and practitioners need to understand the influence of the delivery context on student experiences to optimize after-school STEM programs for an in-school delivery.

Theoretical framework

Self-determination theory

Self-determination theory (Deci & Ryan, 2000) provides a framework to examine how learning contexts support or undermine student learning experiences. It is particularly useful for this study in that it transcends the optimization of learning contexts and extends to learning-supportive constructs that operate in-school, at home, after-school, and other contexts. These constructs then contribute to the development of engagement and interest that are so vital to STEM learning, persistence, and career intention (Jang, Kim, & Reeve, 2012; Lavigne, Vallerand, & Miquelon, 2007).

Psychological needs

At the core of self-determination theory are three innate and universal psychological needs that permeate all people, contexts, and situations, namely competence, autonomy, and relatedness. Competence is the need for effectiveness and capability to yield desirable outcomes (White, 1959). Students who feel competent are able to experience success when completing tasks and have a sense of content mastery (e.g., “I am good STEM!”). Autonomy is the need for choice, to act in line with personal values and goals, and be self-directed (deCharms, 1968). Autonomy is not a sense of complete control, instead, positive perceptions of autonomy enable students to willingly comply to requests as they are able to share opinions and feedback, understand how tasks are important and relevant to them, and act according to their own sense of volition (e.g., “I have some choices in my STEM class.”). Relatedness is the need to be connected and close to others (Baumeister & Leary, 1995). Students with robust perceptions of relatedness carry out positive social interactions with their peers and teachers, develop strong social bonds, and feel like they are welcomed and belong (e.g., “I feel valued and supported by my STEM teacher and peers!”). The three psychological needs are positioned as direct predictors of individuals’ reasons for participation in an activity or context, in other words, their motivation.

Motivation regulations

Self-determination theory defines a series of motivation regulations by their relative level of self-determination or free will. The motivation regulations include intrinsic motivation, identified regulation, introjected regulation, and external regulation. More self-determined motivation reflects participation for reasons that emanate from within the self (i.e., intrinsic motivation and identified regulation) and less self-determined motivation reflects participation for reasons that emanate from outside of the self (i.e., introjected and external regulation) (Deci & Ryan, 1985; Ryan & Deci, 2000). The most self-determined form of motivation is intrinsic

motivation and represents participation for fun and enjoyment. Students participate because they are genuinely interested in the task itself and not any outcomes it may yield (e.g., “Learning about STEM is fun!”). After intrinsic motivation, the external regulations (i.e., identified regulation, introjected regulation, and external regulation) progressively represent participation for reasons that are more external to the self and are less self-determined. Unlike intrinsic motivation, each of these regulations captures participation in a task for reasons outside of the task itself. Identified regulation represents participation because it is a personally important value or goal. Students with a more identified regulation participate in activities because it holds an instrumental, but personal, importance (e.g., “Building STEM skills is goal of mine.”). Introjected regulation represents participation to avoid feelings of guilt or to preserve feelings of pride. Students with a more introjected regulation feel pressure to participate from within and may take part in activities so teachers will think they are good students or so they will not feel bad from not taking part (e.g., “I try hard during STEM activities because I’ll feel guilty if I don’t.”). External regulation represents participation to earn a reward, avoid punishment, or to comply with controls outside of the self. Different from the internal pressures experienced with introjected regulation, external regulation represents participation for reasons completely external to the self. Students complete activities, try hard to win a prize or avoid bad grades because they feel like that it is what they are supposed to do (e.g., “I do STEM activities so my teacher won’t punish me.”).

Socio-contextual variables

Self-determination theory posits that there are also three socio-contextual variables (i.e., autonomy support, involvement, and structure) that can support perceptions of psychological need satisfaction and more self-determined forms of motivation. In academic contexts, teachers are a primary source of these desirable interpersonal interactions as they design, deliver, and manage the classroom environment. When applied to the academic context, teachers demonstrate autonomy support by valuing their students’ perspectives and feelings, offering opportunities for choice, and yielding control (Deci & Ryan, 1991). Autonomy supportive teachers take time to listen to their students, and, when possible, accommodate their suggestions, or at least explain the rationale for the given instructions or rules (e.g., “My teacher provides options for us to complete assignments.”). Teachers who provide structure establish guidelines and consistently provide feedback to help individuals successfully meet expectations (Standage, Duda, & Ntoumanis, 2005). The need for a structured learning environment is critical for student achievement. Students need pathways to success that are consistent, fair,

and clearly communicated. Further, students require support to learn how to comply to set expectations and guidelines (e.g., “I know what my teacher expects of me.”). Involved teachers work to establish caring relationships that provide needed emotional and instrumental support (Deci & Ryan, 1991). Students need to feel cared for, and teachers who get to know students show them that they are important and consistently provide support model involvement (e.g., “My teacher is there for me.”). Considering the full self-determination theory model, researchers and practitioners can expect that teachers whose behaviors foster students’ perceptions of autonomy support, involvement, and structure support their students’ perceptions of competence, autonomy, relatedness, and the more self-determined forms of motivation. In turn, these students are more likely to persist in their academic pursuits and seek out similar experiences in the future (Deci, Ryan, & Williams, 1996).

Examinations of self-determination theory in learning contexts

In the academic context, self-determination theory-based models show strong support for the hypothesized associations among student perceptions of teachers, and student psychological need satisfaction and motivation. Specifically, teacher autonomy support, involvement, and structure are consistent, positive predictors of student perceptions of psychological need satisfaction (Chatzisarantis & Hagger, 2009; Cheon, Reeve, & Moon, 2012; Coatsworth & Conroy, 2009; McDavid, McDonough, Blankenship, & LeBreton, 2017; Tessier, Sarrazin, & Ntoumanis, 2008, 2010). Perceptions of teachers are reliable, positive predictors of the more self-determined forms of motivation as well (e.g., Chirkov & Ryan, 2001; Ryan & Patrick, 2001; Vallerand, Fortier, & Guay, 1997; Vansteenkiste et al., 2012).

Self-determination theory-based models have also been effectively utilized to study STEM teaching and learning settings both formal and informal. De Loof, Struyf, Boeve-de Pauw, and Van Petegem (2019) have shown that the provision of structure and support of student autonomy positively predicts students’ more self-determined motivation for and engagement with STEM subjects in school. Studying outreach activities in schools, Vennix, den Brok, and Taconis (2018) demonstrated that the STEM learning environment and characteristics of STEM learning activities are associated with the development of a more self-determined motivation for STEM learning. Additionally, Salmi and Thuneberg (2019) used a self-determination model of learning to examine how motivation and engagement for science learning differ between school and informal learning environments. They found the informal learning context enhanced autonomy support and intrinsic motivation for learning.

The associations among teacher interpersonal behaviors and the less self-determined forms of motivation are less robust where there are mixed (e.g., non-significant, or weak and positive or negative) associations with introjected regulation and non-significant or weak and negative associations with external regulation (e.g., Lim & Wang, 2009; Pelletier, Fortier, Vallerand, & Briere, 2001). The psychological needs also act as mediators in the association between perceptions of teachers and the motivation regulations (e.g., Goodenow, 1993; Jang, Reeve, & Deci, 2010; Koka & Hagger, 2010; Ntoumanis, 2005; Ryan, Stiller, & Lynch, 1994; Tucker et al., 2002; Vallerand et al., 1997). However, in this body of work, a test of a model that includes perceptions of teachers, psychological needs, and each motivation regulation is limited and would offer a thorough examination of theory and a more complete assessment of how learning contexts influence student psychological needs and motivation.

There is also evidence that the learning contexts influence how teachers engage their students. For example, teachers' own psychological need satisfaction and self-determination for work are negatively predicted by their perceptions of job pressure and positively predict their perceptions of adaptive teaching behaviors (Taylor, Ntoumanis, & Standage, 2008). Further, teachers' perceptions of their students' motivation for class influences how they use best teaching practices to engage students (Skinner & Belmont, 1993; Taylor et al., 2008). Therefore, when changing the learning context during program scaling, it is necessary to examine the potential impact on student-teacher interactions and student learning experiences.

Purpose and hypotheses

The purpose of this research was to examine how the learning context, in- or after-school, impacts students' learning experiences in a STEM program for underserved youth. Using the self-determination theory framework, the associations among student perceptions of teachers, psychological need satisfaction and motivation, and the potential effect of learning context on each variable were tested. Based in theory and previous evidence, it was hypothesized that (1) student perceptions of teachers would positively predict their psychological need satisfaction and the more self-determined motivations via direct and indirect pathways, (2) psychological need satisfaction would have a direct and positive association with the self-determined motivation regulations, and (3) student perceptions of teachers and psychological need satisfaction would have non-significant or weak negative associations with the less self-determined motivation regulations. Last, the influence of learning context, operationalized as in-school or after-school, was tested as a predictor of student perceptions of teachers,

psychological need satisfaction, and each motivation regulation via direct and indirect pathways.

Methods

Participants

Students who participated in a technology-focused program hosted by a large Midwestern and small Southeastern University were recruited for this study. In total, 314 students in 19 groups at 16 different schools took part in the program. Two hundred forty-four students (39% girls, 60% boys, $M_{\text{age}} = 13$, $\text{Range}_{\text{age}} = 11\text{--}14$, 63% Caucasian, 18% African American, 6% Multiracial, 5% Latino/a, 4% Asian, 3% others) participated in the program in-school and 70 students (33% girls, 63% boys, $M_{\text{age}} = 12$, $\text{Range}_{\text{age}} = 10\text{--}14$, 55% Caucasian, 16% Multiracial, 13% Latino/a, 8% African American, 8% Latino/a) participated in the program after-school.

Program

The program was designed to introduce middle school students from racially and ethnically diverse backgrounds and from low-income families to develop foundational computing, engineering, and technology skills by challenging them to design a technology-based physically active game, an exergame.

Program administrators invited middle school principals and teachers who taught science, technology, engineering, or physical education courses to implement the program. These professionals were from schools that predominately served students from diverse racial, ethnic, and socioeconomic backgrounds. Those who accepted the invitation took part in a summer professional development training designed to enable teachers to lead their students in a series of skill-building lessons on coding software (e.g., Scratch and nanoNavigator), use of electronic hardware (e.g., wiring, microcontrollers, push-buttons, sensors, and alarms), and on essential program structures and processes, such as how to assign students to roles on their team (e.g., builders, coders, wirers, and social media) and how to engage students using a variety of physical activity games. All teachers received a program toolkit that included a thorough lesson and program manual, hardware, software, and all instructional materials required for exergame development and were provided technical assistance for the duration of the program. Findings from previous iterations of this program implemented in the after-school setting demonstrate that students reported enhanced attitudes toward and interest in technology careers (Weiling, 2017).

Teachers chose to implement the program either in- or after-school based on the needs of their school and students, personal preference, and school fit. If teachers chose to implement in-school, the curriculum was integrated into an existing course or as a standalone course. If teachers

chose to implement after-school, the program was offered as an extra-curricular program. Teachers were able to customize program delivery (e.g., number, frequency, and length of classes/meetings) to accommodate the needs of the schools (e.g., scheduling) and their students (e.g., appropriate pacing). Therefore, the structure of program implementation was quite variable across schools; however, there were standard requirements.

All implementations were required to meet for 30 h and cover 25 lessons at minimum. Although program implementation length and frequency were variable across implementations, groups of students in the in- and after-school contexts spent an average of 13 weeks ($Range_{weeks} = 8-17$) participating in the program and met an average of 4 times per week ($Range_{frequency} = 1-5$), and there were no differences in program length or frequency between learning contexts. The program manual included 17 chapters that included one to three lessons that were designed to last 15–60 min each. Chapters that had multiple lessons were designed to enable teachers and their students to explore more advanced material. Each lesson had stated objectives and indicated how it met one or more standards for grades 6–8 at the state and national levels, and K-12 Computer Science Standards. Lesson topics included how to set up equipment (e.g., how to track steps or heartrate from a fitness band), the history of commercial exergame technology (e.g., use of exercise bikes, fitness activities via gaming consoles, virtual reality); how to use excel to collect, organize, and analyze data; and how to wire electronic components to a microprocessor, the engineering design process, programming, and much more. Lessons also included example activities, problems, and checks for understanding. All teachers were encouraged to allow students time to play and experiment with the technology throughout program implementation. Teachers were also encouraged to integrate “brain blasts” where students would complete a physical activity that challenged them to perform a coordinated movement and, thus, wake up their bodies and minds. Many of these brain blasts were practiced by the teachers during their summer professional development training.

All lessons and activities helped teachers and their students develop the technology, engineering, computing, and creativity skills needed to develop their exergame. In this culminating project, students were grouped into sub-teams that were in charge of a specific component of the project. Suggested duties for each sub-team were provided and included building the physical exergame, developing the flowchart program to make their exergame function, writing advertising materials to share their experience with others, and programming a Scratch animation to visually explain their exergame to others. All student work culminated in a presentation and demonstration of their exergame at a school or community event. At the end of each fall semester, teachers and

their students had an opportunity to qualify for a program-wide end of project showcase, where selected schools would present their exergame at a host institution and compete for a trophy of excellence.

Procedures

After receiving exempt status by the university’s institutional review board, research information sheets were distributed to students and their guardians. Two cohorts of students, those who participated in either the fall or spring of an academic year, were invited to participate in this research.

All surveys were administered at the end of program implementation and were conducted using an online platform during program time. Students took an average of 14 min to complete the survey. The surveys included student demographic information and measures that assessed students’ perceptions of teacher provision of autonomy support, structure, and involvement and perceptions of competence, autonomy, relatedness, and motivation in the program.

Measures

Student perceptions of autonomy support, involvement, and structure were measured using three subscales from the teachers as social context short-form questionnaire (Wellborn, Connell, Skinner, & Pierson, 1988). Wellborn et al. developed the short-form questionnaire by selecting items from the full-length, 52 item scale, that best captured the theoretical structure of each behavior and preserved scale performance. In the final short-form version, each subscale consisted of eight items and was measured on a four-point scale ranging from 1 (*not at all true*) to 4 (*very true*). Each scale demonstrates adequate reliability and validity in populations of similar age and from diverse backgrounds and learning contexts (McDavid et al., 2017; Wellborn et al., 1998).

Student perceptions of psychological need satisfaction were assessed using 16-total items to measure perceptions of autonomy (6 items), competence (5 items), and relatedness (5 items) (Standage et al., 2005). Each measure was organized on a seven-point scale that ranged from 1 (*strongly disagree*) to 7 (*strongly agree*) and was modified to refer to the program context. Each scale shows adequate reliability and validity with students of similar ages in academic contexts and diverse populations (McDavid et al., 2017; Standage et al., 2005).

Motivation for participation in the program was assessed using the Academic Self-Regulation Questionnaire (Ryan & Connell, 1989). Students answered eight questions for each motivation regulation (external regulation, introjected regulation, identified regulation, and intrinsic motivation) that followed a modified prompt to refer to the learning context instead of in-school

classwork. Each item was assessed on a four-point scale ranging from 1 (*not at all true*) to 4 (*very true*) where higher scores indicated greater endorsement of that motivation regulation. The questionnaire was designed and validated for young adolescents in late elementary and middle school, from diverse socioeconomic backgrounds and had demonstrated adequate internal reliability and predictive validity in diverse samples of young adolescents (Grolnick, Ryan, & Deci, 1991; Ryan & Connell, 1989).

Demographic information collected from students included their gender, race, and age.

Data analysis

Preliminary data analysis was conducted in SPSS (25), and the main analyses were conducted in AMOS (25). To prepare for data analyses, all data were screened, including the testing of multivariate assumptions (Tabachnick & Fidell, 2018). Then, descriptive statistics for each group and correlations among all variables were calculated.

For the main analyses, structural equation modeling was used to test the hypothesized and theoretical associations among students' perceptions of teachers, psychological need satisfaction, and motivation, and to test the potential influence of the learning context on each variable. As depicted in Fig. 1, the model was structured as a mediational chain, where learning context was entered as a direct predictor of students' perceptions of their teachers, which in-turn predicted psychological need satisfaction, which in-turn predicted each motivation regulation. Therefore, the effect of learning context has the potential to indirectly predict students' motivation via their perceptions of teachers and psychological need satisfaction, and perceptions of teachers may predict motivation via psychological need satisfaction. However, while controlling for these indirect effects, it is likely that direct associations between learning context and perceptions of teachers remain (Little, 2013). Therefore, the potential for these unmediated effects was entered as a direct path from each variable in the model to all subsequent variables. For example, the learning context was entered as a direct predictor of psychological need satisfaction and each motivation regulation. In this model, predictive associations between learning context represent the effect of learning context when controlling for all other paths in the model.

The learning context was modeled as a dummy-coded variable, where 0 represented students who participated in-school and 1 represented students who participated after-school. Student perceptions of their teacher and psychological need satisfaction were modeled as two latent variables each with three manifest indicators of their retrospective theoretical dimensions. Student perceptions of motivation were modeled as individual latent variables with single manifest indicators that were averages of all items in each measure.

All indirect effects were evaluated using bias-corrected bootstrap-generated 95% confidence intervals. In addition, the magnitude of the direct and indirect associations and variance explained in each dependent variable were considered. To determine the overall measurement and structural model fit, thresholds were set at root mean-square error of approximation (RMSEA) values less than .08, Tucker-Lewis coefficient (TLI) values greater than .90 and Comparative Fit Index (CFI) values greater than .90 (Little, 2013).

Results

Preliminary analyses

Preliminary analyses evidenced no univariate or multivariate outliers, and the data were approximately normally distributed and linear. Descriptive statistics including standard deviations, ranges and means for each learning context, and the correlations and internal consistencies are presented in Table 1.

The point-biserial correlations indicated that learning context, entered as 0 = *in-school*, 1 = *after-school*, was positively associated with students' perceptions of autonomy and negatively associated with introjected and external regulation. Therefore, both increasing perceptions of autonomy and decreasing perceptions of introjected and external regulation were associated with the after-school context. The remaining Pearson correlations among students' perceptions of their teachers and perceptions of psychological need satisfaction and the more self-determined motivation regulations were significant and positive. Students' perceptions of teacher autonomy support and involvement also had significant and negative associations with external regulation. Perceptions of autonomy were negatively associated with external regulation and perceptions of competence were positively correlated with introjected regulation. Introjected regulation was significantly and positively associated with each motivation regulation, and external regulation was significantly and positively correlated with identified regulation. Students' responses in both implementation contexts were, on average, positive and near the upper end of the scale. In both contexts, reports of introjected ($M = 2.31-2.63$) and external regulation ($M = 2.08-2.59$) were relatively lower than the more self-determined motivations ($M = 3.01-3.20$) and nearer to the middle of the scale. All scales demonstrated adequate internal consistencies.

Before testing the structural model, a measurement model was tested that included the latent variables for students' perceptions of teachers with manifest indicators of autonomy support, involvement, and structure and psychological need satisfaction with manifest indicators of autonomy, competence, and relatedness. The measurement model demonstrated adequate fit (RMSEA = .10, TLI = .95,

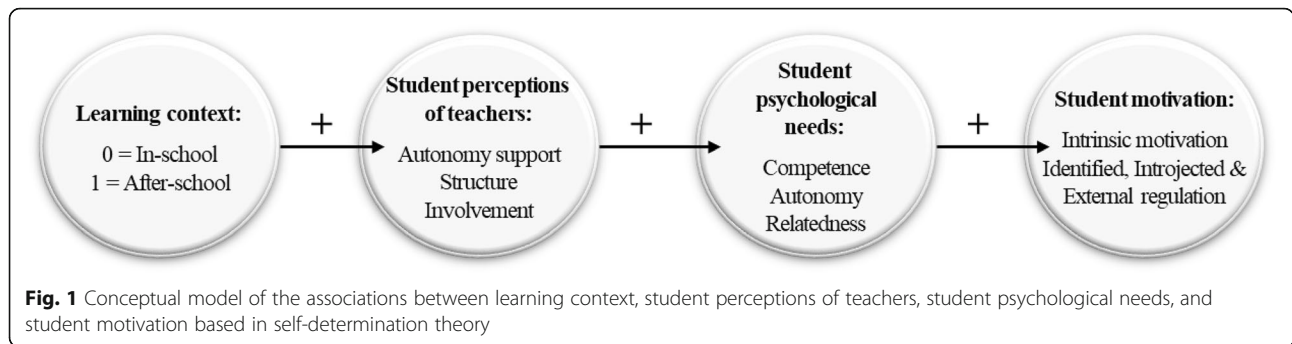


Fig. 1 Conceptual model of the associations between learning context, student perceptions of teachers, student psychological needs, and student motivation based in self-determination theory

CFI = .97), and indicator loadings were all significant ($p < .01$) and ranged from .64–.86.

Main analyses

Results from the structural equation model and fit statistics are presented in Fig. 2. The model predicted 20% of the variance in the psychological needs and 6–35% of the variance in the motivation regulations. The theoretical associations among student perceptions of their teachers, psychological need satisfaction, and the motivation regulations follow the hypothesized and evidenced pathways. Student overall perceptions of teachers had significant, direct, and positive associations with students’ overall psychological need satisfaction ($\lambda = .44, p < .05$), intrinsic motivation ($\lambda = .17, p < .05$), identified regulation ($\lambda = .20, p < .05$), and a significant, direct, and negative association with external regulation ($\lambda = -.15, p < .05$). The path between perceptions of teachers and introjected regulation was not significant ($\lambda = -.06, p > .05$). Students’ perceptions of psychological need

satisfaction positively predicted their intrinsic motivation ($\lambda = .49, p < .05$) and identified regulation ($\lambda = .41, p < .05$) and had a positive but weaker association with introjected regulation ($\lambda = .15, p < .05$). The path between psychological need satisfaction and external regulation was not significant ($\lambda = -.00, p > .05$). In addition to the significant direct associations, the psychological needs mediated the association between students’ perceptions of their teachers and intrinsic motivation ($\beta = .22, 95\% \text{ CI} = .21, .36$), identified regulation ($\beta = .18, 95\% \text{ CI} = .15, .28$), and introjected regulation ($\beta = .07, 95\% \text{ CI} = .04, .13$). There was no mediated effect for external regulation ($\beta = -.00, 95\% \text{ CI} = -.05, .06$).

When controlling for all other paths in the model, the learning context had direct, negative, and significant associations with student perceptions of introjected ($\lambda = -.21, p < .05$) and external regulations ($\lambda = -.27, p < .05$). There were no significant associations between the learning context and student perceptions of teachers ($\lambda = .05, p > .05$), psychological need satisfaction ($\lambda = .07, p > .05$),

Table 1 Correlations, Cronbach’s alpha, and descriptive statistics

	1	2	3	4	5	6	7	8	9	10	11
1. Learning context	–										
2. Teacher autonomy support	.08	.77									
3. Teacher involvement	.04	.59*	.79								
4. Teacher structure	-.01	.74*	.65*	.80							
5. Autonomy	.14*	.59*	.44*	.52*	.77						
6. Competence	.07	.44*	.45*	.40*	.54*	.83					
7. Relatedness	-.02	.42*	.45*	.42*	.47*	.49*	.93				
8. Intrinsic motivation	.11	.50*	.38*	.40*	.54*	.58*	.43*	.82			
9. Identified regulation	-.01	.49*	.36*	.42*	.49*	.45*	.41*	.74*	.79		
10. Introjected regulation	-.20*	-.04	.06	.07	.09	.12*	.08	.23*	.39*	.78	
11. External regulation	-.28*	-.25*	-.11	-.15*	-.15*	-.05	-.01	-.08	.12*	.72*	.83
Mean _{Inschool}	–	3.19	3.26	3.27	5.11	5.34	5.74	3.01	3.13	2.63	2.59
Standard Deviation _{Inschool}	–	.55	.59	.59	1.18	1.20	1.20	.72	.64	.66	.72
Mean _{Afterschool}	–	3.29	3.20	3.32	5.48	5.56	5.70	3.20	3.11	2.31	2.08
Standard Deviation _{Afterschool}	–	.50	.56	.53	.98	1.17	1.27	.72	.75	.65	.75

Note: Program context is coded as in-school = 0 and after-school = 1. Cronbach’s reliability coefficient reported in bold along the diagonal

* $p < .05$

intrinsic motivation ($\lambda = .06, p > .05$), or identified regulation ($\lambda = - .06, p > .05$). The learning context did not have any significant indirect associations, except for a positive but weak path with intrinsic motivation ($\beta = .05, 95\% \text{ CI} = .01, .17$).

Discussion

Integrating after-school programs into the school day creates new opportunities to provide needed supplemental STEM education to more students without the substantial investments required to develop new curriculums. The implications of increasing reach can be long term as these programs build STEM skills, encourage interest in STEM, and, ultimately, foster the pursuit of STEM careers (National Research Council, 2015; Young et al., 2017). However, as self-determination theory posits, change in learning context could impact the efficacy of such programs. In the current research, the potential influence of the learning context was examined on the proposed self-determination theory-based model. Findings followed the hypothesized associations where student perceptions of teachers positively predicted their psychological need satisfaction and self-determined motivation via direct and indirect pathways. Students’ psychological need satisfaction positively predicted more self-determined motivation as well. Students’ perceptions of teachers also had a significant and negative association with external regulation and psychological need

satisfaction significantly and positively predicted introjected regulation. Learning context did have significant and negative associations with student’s introjected and external regulations, above and beyond students’ perceptions of teachers and psychological need satisfaction, but students in both contexts had similar perceptions of their teachers, psychological need satisfaction, and more self-determined forms of motivation.

Students’ perceptions of teachers

The performance of the theory-based model replicated the large body of evidence that demonstrates how student perceptions of teachers’ autonomy support, involvement, and structure positively predict their perceptions of competence, autonomy, relatedness, and motivation (e.g., Ryan & Patrick, 2001; Vansteenkiste et al., 2012). Further, previous research has demonstrated similar magnitude for variance explained in perceptions of significant others predicting psychological need satisfaction ($R^2 = .17-.48$), and perceptions of significant others and the psychological needs predicting motivation regulations ($R^2 = .07-.46$) in samples of similar age (e.g., McDavid, Cox, & Amorose, 2012; Reynolds & McDonough, 2015; Sierens, Vansteenkiste, Goossens, Soenens, & Dochy, 2009; Zhou, Ntoumanis, & Thogersen-Ntoumani, 2019). Considering the current and previous research, teachers whose behaviors create opportunities for

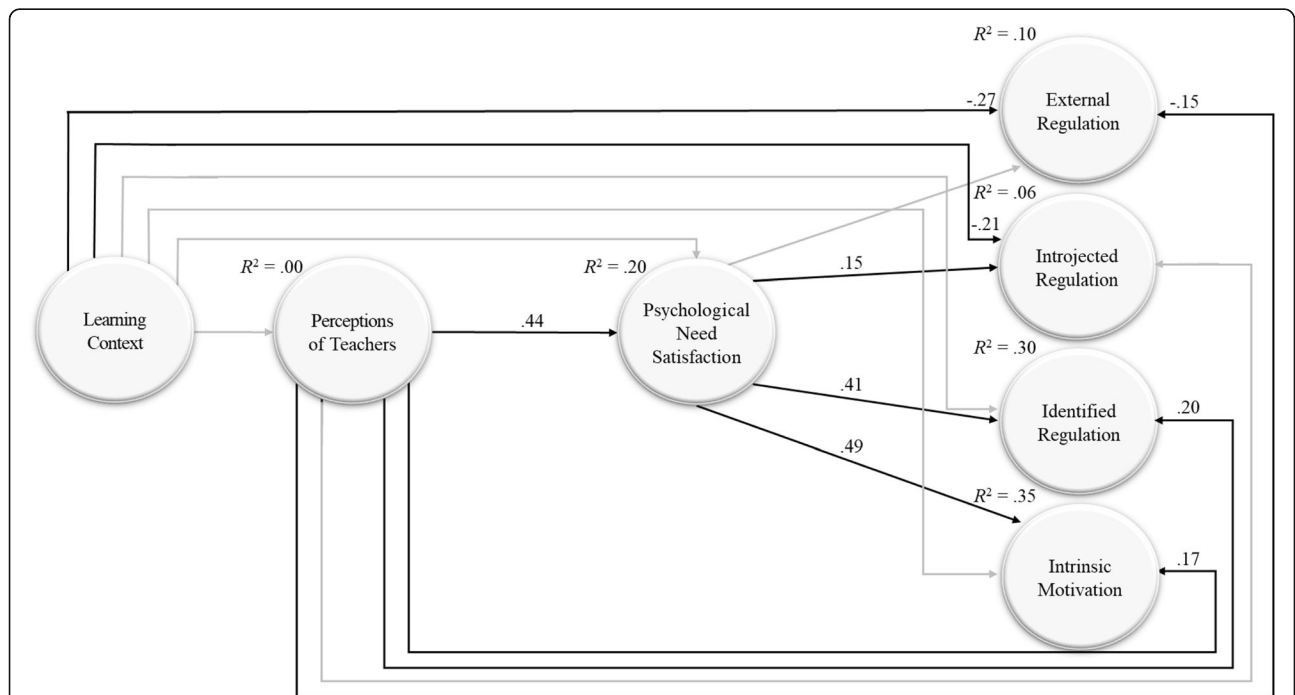


Fig. 2 Results of structural equation model that tests the effect of program delivery context on students’ experience based in self-determination theory. Standardized solutions reported. Significant paths are in black and non-significant paths are in gray. Indirect associations are not depicted but were included in the analyses. The effects for gender and race/ethnicity were tested but were not significant and were excluded from the final model. RMSEA = .07; $p_{close} = .05$; TLI = .95; CFI = .98

choice, support perceptions of control, interact warmly with their students, and set rules and expectations that guide student behavior and success help students feel connected to others, effective, and able to act in accordance to their own volition. Further, student perceptions of these adaptive behaviors enable desirable motivation for participation. Specifically, students report that they take part in learning activities because it is fun and aligns with who they are and their personal goals, and are less likely to report that they participate to avoid punishment or to earn a reward. Such findings are important in the STEM context as program administrators, and teachers can target the specific mechanisms in the learning context to improve student experiences in and motivation for STEM learning.

Previous evidence demonstrates that teachers who cultivate a positive learning context, through their use of these desirable behaviors, enable students build internal assets and motivational profiles that are poised to support continued participation and pursuit of similar learning experiences in the future (Deci & Ryan, 2008). Just as teacher behaviors support desirable outcomes, they can also reduce the likelihood of their students having negative learning experiences, or participating due to guilt, to avoid punishment or to gain a reward. When considering in-school and after-school STEM programs, a hallmark of program success is for students to seek opportunities that further develop and apply their skills in new contexts (Hagger & Chatzisarantis, 2016). Prior work on the role of motivation in science learning indicates that the cultivation of intrinsic motivation (unlike extrinsic motivation) is directly linked with science engagement and achievement (Lee, Hayes, Seitz, DiStefano, & O'Connor, 2016). The current study suggests that student perceptions of autonomy-supportive, involved, and structured practices can foster the development of intrinsic motivation and identified regulation in students. The current findings underscore the influence of teachers on preparing and motivating students to pursue STEM careers.

Students' psychological need satisfaction

Student perceptions of competence, autonomy, and relatedness positively predicted their intrinsic motivation and identified regulation. These paths indicate that as students feel more effective, act in accordance with their personal goals and will, and are connected to others, they participate for fun and enjoyment and to learn skills that contribute to their sense of self (Deci & Ryan, 2000). The marginal and non-significant paths between the psychological needs and less self-determined motivation regulations echo previous findings. Research shows that introjected regulation can align with the more self-

determined forms of motivation and that asset-building experiences enhance desirable motivational outcomes or promote internalization (Pelletier et al., 2001). However, it is the strong and positive associations between the psychological needs and self-determined forms of motivation that demonstrate the benefit of cultivating student competence, autonomy, and relatedness to support their motivational well-being and persistence in STEM studies (Jang et al., 2012).

Role of the learning context

Self-determination theory recognizes that learning occurs in social contexts that influence students' perceptions of their teachers, psychological need satisfaction, and both adaptive and maladaptive forms of motivation. In the current study, the role of learning context, either as an in-school or after-school program, was entered as a direct, and when appropriate, an indirect predictor of student perceptions. In both contexts, students agreed that, overall, their teachers modeled autonomy support, involvement, and structure when leading the program and had similar perceptions of psychological need satisfaction. However, when examining the motivation regulations, learning context did predict greater introjected ($M_{\text{difference}} = .32$) and external motivation regulations ($M_{\text{difference}} = .51$) for students who participated in-school versus after-school controlling for all other paths in the model (i.e., learning context predicted unique variance above and beyond students' perceptions of teachers and psychological need satisfaction). These associations between context and the less self-determined motivation regulations suggest that when the program is delivered during the school day, students are more likely to associate feelings of guilt and external control with their participation or connect their participation to an anticipated reward or punishment. Any differences across contexts did not hold for the more self-determined motivations, as participation for fun and because it is personally important was similar for all students.

Implications of changing program delivery contexts

The effect of the learning context on variables within the theoretical model demonstrates some potential consequences of transferring or duplicating STEM programs from the after-school to the in-school context. Traditionally, the after-school context is one where students elect to spend their free-time pursuing their interests and passions (e.g., STEM clubs, art, drama, music, and athletics). This after-school time is set apart from the daily demands and expectations of in-school activities as their participation is often for fun, to develop social relationships and to enhance skills. While in-school, students may find the reason for their participation is influenced by other external demands and rewards, such

as grades, teacher approval, pressures of performance, and the simple fact that they are required to attend and complete their work. The findings of the current study demonstrate that these context-specific expectations and goals still operate as motivators for students, even when the learning activities were originally designed for more informal settings. To help more students engage in STEM and have desirable experiences doing so, STEM program administrators cannot assume that transferring an after-school program to in-school will have similar, desired effects. Instead both the constraints (e.g., mandatory participation and grades) and levers (e.g., increased reach and more teacher availability) of the learning context need to be considered.

Applications of this finding show promise for other STEM programs considering a shift in learning context as, in the current research, program implementation (e.g., number of meeting days, ordering of lessons) was quite variable as teachers were given the leeway and control to lead the program as needed for their students and school. Despite this variability, the learning context was still a significant predictor. Thus, the study design and findings offer a real-world test of the theory that offers in situ applications that can be applied to other STEM programs with alternate designs.

Considerations for future research and limitations

Previous research demonstrates that the demands, expectations, and interactions between students and teachers in a given context can influence learning outcomes by changing how teachers behave (Skinner & Belmont, 1993; Taylor et al., 2008). However, in the current study, student perceptions of teachers were similar across contexts. Although the inherent demands on teachers during school (e.g., more formal and structured) and after-school (e.g., more informal and relaxed) may be different, in the current sample, teachers in both contexts were perceived as engaging students using autonomy support, involvement, and structure. Future research may want to consider learning contexts and programs where teachers do not self-select to deliver a new STEM curriculum. Just as a lack of autonomy can undermine student motivation and affect their motivation for participation, teachers who are required to deliver a program may be more likely to engage students using less desirable interpersonal behaviors that have negative consequences for their students.

As practitioners and researchers consider the learning context of STEM programs, the evaluation of social, intra-personal, and motivational factors can help guide their implementation, interpret their findings, and explain the impact. Future research can build on these findings by examining the consequences of learning context-dependent motivation by including common outcomes of the motivation regulations (e.g., persistence, enjoyment, and skill building). Future research should also consider the role of psychological need frustration to test how the suppression

of students' perceptions of competence, autonomy, and relatedness predicts each motivation regulation and is potentially influenced by learning context (Vansteenkiste & Ryan, 2013). The inclusion of student interview data could help elucidate the underlying factors (e.g., established structures and processes) that undergird student perceptions of motivation and learn how to fortify the role of desirable (e.g., fun and learning) and dismantle the impact of undesirable (e.g., grades and required participation) factors on their learning experiences in-school. Further, during early adolescence, peers are highly influential and the impact of the quality of peer connections within and across learning contexts should be considered.

Other limitations of this work include the cross-sectional and observational design. Longitudinal research or an experimental design would offer a more rigorous test of theory to examine if there are initial differences in psychological need satisfaction and motivational across learning contexts, and how students' perceptions of teachers predict a change in psychological need satisfaction and motivation. Another important limitation of the observational design of this research is that teachers were given the option to choose an in- or after-school implementation. Without the random assignment of learning context, there could be confounders that influence the degree that the learning context predicts variables in the model that were not accommodated in the current design.

Conclusions

Findings from the current study demonstrate the important role of student perceptions of teachers and psychological need satisfaction on their reasons for participation in a STEM learning program. Further, the influential role of the learning context (i.e., in-school versus after-school) was demonstrated as even when perceptions of teacher behavior and psychological assets are similar, the learning context still predicted student motivation for participation. Future research should continue to consider the interplay between learning contexts and student outcomes and work to design evidence-based STEM curriculums that accommodate established structures and processes to better enhance student motivational processes that are influenced by learning context. These findings contribute to the evidence base on how to better leverage opportunities to increase student exposure to supplemental STEM learning experiences and, ultimately, motivate young people to pursue STEM education opportunities and careers.

Supplementary information

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Additional file 1. Student Survey.

Abbreviations

STEM: Science, technology, engineering and math

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Authors' contributions

Lindley McDavid: Conception and design of research, acquisition, analysis, and interpretation of data, drafting, and revision of the work. Loran Carleton Parker: Conception and design of research, acquisition, analysis, and interpretation of data, drafting, and revision of the work. Weiling Li: Analysis of data and revision of the manuscript. Ann Bessenbacher: Acquisition and analysis of data and drafting of the work. Anthony Randolph: Acquisition of data and drafting of the work. Alka Harriger: Revision of the manuscript and acquisition of data. Brad Harriger: Acquisition of data and revision of the manuscript. The author(s) read and approved the final manuscript.

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Our IRB approval did not include the use of data beyond the scope of this project. We are corresponding with our IRB to determine if this data could be made available without breaching our research protocol.

Ethics approval and consent to participate

This research project was granted IRB approval and adhered to other ethical standards as put forth by the American Psychological Association, federal regulations, and our institutions were followed in the conduct of the work. The research was IRB approved at Purdue University as exempt (Protocol #: 1702018763) and all participants and, when required, guardians, were provided with research information sheets before their participation.

Consent for publication

Not applicable

Competing interests

Not applicable

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