INCREASING STEM LEARNING TO BOOST THE SECOND SPACE RACE. J. Carmona Reyes[1], A. Carballido[1], J. York[2], K. Brady[3] and T. W. Hyde[1], [1]CASPER (*Center for Astrophysics, Space Physics and Engineering Research), 100 Research Pkwy, Waco, Texas 76704.* Jorge_Carmona_Reyes@baylor.edu, [2]Education Service Center Region 12, *2101 W Loop 340, Waco, TX 76712*, [3]Huckabee, Inc. *801 Cherry St Ste 500, Fort Worth, TX 76102*

Introduction: Space exploration and the challenges that came with the first space race (1957 - 1969) dramatically increased interest in STEM. However, later a decreased interest in STEM areas was widely documented in multiple policy reports [1]. These reports all conclude that despite the best efforts of both government and private sectors STEM interest continues to deteriorate. The "Rising Above the Gathering Storm" 2005 report concludes that "our primary and secondary schools do not seem able to produce enough students with the interest, motivation, knowledge and skills they will need to compete and prosper in the emerging world" (pg. 94). NASA's endorsement of the second space race (e.g., Space X, XCOR, etc.) [2] provides the opportunity for STEM interest to increase once more. Maximizing this opportunity will require a new focus on interventions, curricular material, preparing teachers through tailored professional development and maximizing the use of the learning environment to increase STEM interest to support this opportunity. This paper shows that research-based efforts to increase STEM can be used to guide such an effort and are effective even in the middle of global disruptions such as the Covid-19 pandemic.

Student Engagement: In March of 2019 when schools rapidly transitioned to online learning, the impact of Covid on student engagement, learning skills (e.g., communication and critical thinking) and overall STEM learning and interest decreased due in part to lack of educational access and technological issues [3]. Multiple publications have discussed the negative impact of the pandemic on education [4],[5]; however, recent findings of a student engagement study [6] show that regardless of the time period (i.e., pre-pandemic or pandemic) or method of delivery (online or face-to-face) successful STEM learning can occur when student engagement stays constant.

Based on eight years of research, the authors have produced a definition of student engagement at the elementary school level comprised of Behavioral Engagement (e.g., effort, participation), Cognitive Engagement (e.g., autonomy and competence with school academic work) and Emotional Engagement (e.g., students' sense of belonging and relationships with all members of their school community).

It has also been shown that this latent variable may be measured using properly calibrated instruments. The instruments used here are based on both a theoretical and statistical analysis where a Rasch statistical model estimates a linear scale and produces scores based on the raw scores (i.e., Likert scale) produced by the measuring instruments. This is accomplished using a Conditional Maximum Likelihood Estimator with the estimated scores then used to compare between the different groups (i.e., face-to-face and online) .

Research Design. A longitudinal study was conducted in a US Mid-Western Independent School District (ISD) during the 2020-2021 academic year. The research sample consisted of approximately 250 participants distributed within the 2^{nd} – 4^{th} grade of two elementary school campuses. Participants had the option (every six weeks) to participate in either online or face-to-face instruction. Self-reported data was collected in the middle of these six-week periods with independent observational data collected on a bi-monthly basis. Student engagement was observed as well as learning skills, use of the learning environment and levels of flexibility and furniture choice. This research study was designed by the authors as a continuation of a 2019-2020 longitudinal study that measured student engagement for students provided with flexible learning spaces and having teachers with tailored Professional Development (PD) that allowed them to maximize the use of the space as a pedagogical tool across the spectrum of learning skills.

Results: Six waves of data were collected using self-report instruments (from both teachers and students) and analyzed. In addition, 16 independent observations were also collected and analyzed. On average, 25 participants were involved in online instruction with 225 participants face-to-face. On average, results in levels of student engagement (see fig. 1) show that when comparing pre-pandemic to pandemic data there was a slight decrease in both the cognitive and emotional engagement components; however, all levels (including these) remained above the average.

When comparing student engagement data from both the student and teacher perspective and then comparing between face-to-face and online groups during the pandemic period, on average there was no statistically significant difference between the groups (i.e., face to face and online) (see Fig 2). Also, no statistically significant difference was found in the

teacher data between the face-to-face group and the virtual group (see Fig 3).

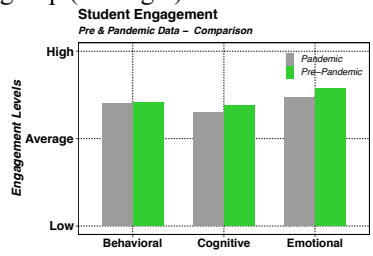

Figure 1. Comparison of student engagement levels indicate that the emotional and cognitive components showed the most significant decrease among all components.

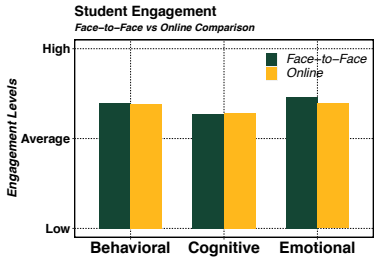

Figure 2. Comparison of student engagement levels (student data) between face-to-face and online groups during the pandemic academic year (2020-2021).

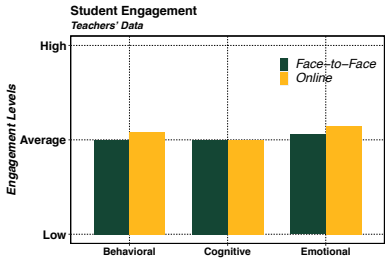

Figure 3. Comparison of student engagement levels (teacher data) between face-to-face and online groups during the pandemic academic year (2020-2021).

Examination of student engagement observation data throughout the 2020-2021 school year (See Fig. 4) shows that on average, there is a minimal statistically significant difference between the face-to-face and online groups closely resembling the trend reported by participating teachers and students. Although the overall observed level of student engagement (i.e., emotional, cognitive and behavioral engagement) *was* below average, there was no negative or decreasing trend throughout the year. Additionally, when looking at learning skills observed during the pandemic period (i.e., the 2020-2021 academic year), (see Fig 5) no statistically significant difference between the face-to-face group and the online group was detected although both groups exhibit a small increase in learning skills as the academic year progressed.

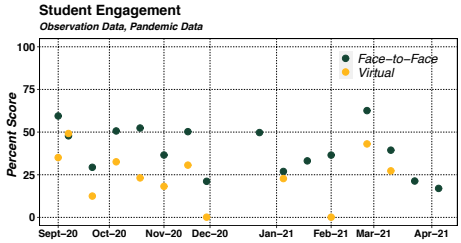

Figure 4. Comparison of student engagement levels (observation data) between face-to-face and online groups during the pandemic academic year (2020-2021).

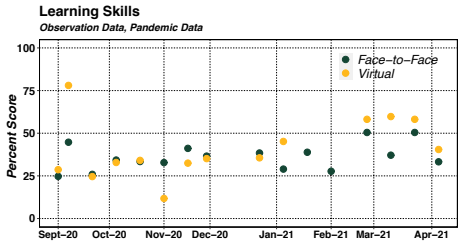

Figure 5. Comparison of Learning Skills levels (observation data) between face-to-face and online groups during the pandemic academic year (2020-2021).

Future Work: These results indicate that the impact of the pandemic on students in a school district with tailored professional development and a flexible learning environment may not have been as punitive as what has recently been published. However, to increase result validity, this study will be replicated for a different school district where no tailored PD and flexible learning environment is provided and results compared. Either way, these results appear promising as they demonstrate that STEM learning can remain constant or increase when tailored PD is provided even in the middle of a major disruption such as the Covid-19 pandemic.

References: [1] Suter, L. E., & Camilli G. (2019) Journal of Science Education and Technology 28.1, 52-61. [2] Grubbs, M. (2014). Technology and Engineering Teacher, 74(2), 24. [3] Slavin, R. E., & Storey, N. (2020). Best Evid Chin Edu, 5(2), 617-633. [4] Kuhfeld, M. et al. (2020). Educational Researcher, 49(8), 549-565. [5] Engzell, P., Frey, A., & Verhagen, M. D. (2021). Proceedings of the National Academy of Sciences, 118(17). [6] Carmona Reyes, J. et al. (2021) *LPS LII,* Abstract #1144.