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Shifting from Face-to-Face Instruction to Distance Learning of Science in China and Israel During COVID-19: Students' Motivation and Teachers' Motivational Practices

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Abstract
Science teachers in many countries were required to shift from face-to-face (F2F) instruction to distance learning (DL) during the COVID-19 pandemic. With the aim of helping science teachers learn how to support their students in negotiating such shifts in the future, we used an online motivation survey based on achievement goal theory to investigate the shifts to over two thousand 8th grade students' perceptions of their science teachers' motivational practices and their own goal orientations towards science that occurred during the transition from F2F instruction to DL in two very different countries, China and Israel. We hoped to identify issues common to both countries, assuming that these issues might be relevant to other countries as well. Factor analysis, t-tests, and multiple regression were used to identify key teacher motivational practices, changes to these practices and to students' goal orientations, and relations between teacher practices and student goal orientations. The major predictor of students' mastery orientation towards science in both F2F instruction and DL, teachers' attentiveness to their students' need to understand, declined for students in both countries during the shift from F2F to DL, and was associated with a decline in students' mastery orientation, engagement, and enjoyment.

Keywords Distance learning · Goal orientation · COVID-19 · Teaching practices

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Introduction

With the outbreak of the COVID-19 pandemic, science teachers in many countries were required to shift from face-to-face (F2F) instruction to distance learning (DL). Distance learning was for many teachers a new instructional environment, placing new professional demands on them. There is no guarantee that teachers who were experts at facilitating F2F learning would be as successful at DL, as instructional practices that are effective in F2F instruction may not be feasible in DL, and even if they are, they may not be as effective.

One of the primary goals of middle school science instruction is to maintain and enhance students' motivation to engage with science, a characteristic which has been repeatedly shown to decline during adolescence (Galton, 2009; Osborne et al., 2003; Vedder-Weiss & Fortus, 2011). Motivation is important because without it, little engagement can be expected, and without engagement, little learning will occur. Science teachers are significant adults in influencing adolescents' motivation to engage with science, but their influence is mediated by students' perceptions of their intentions. Therefore, it is important to consider students' interpretations of their teachers' practices and messages when investigating the relations between teachers' practices and students' affective stances (Meece et al., 2006; Vedder-Weiss & Fortus, 2012).

While the motivation to learn science was possibly impacted by the shift from F2F to DL, the ways in which these changes occurred were likely influenced by local conditions–cultural background of the students and teachers, differing access to technology, differing institutional expectations and constraints, and so on. The purpose of this study was to investigate and compare the shifts that occurred in two very different countries — China and Israel — in 8th grade students' affective stances towards science, in their perceptions of their science teachers' motivational practices, and in the relations between them, to give perspective on how local conditions may have shaped the transition from F2F instruction of science to DL of science, and from this to learn how to help teachers and students negotiate transitions from F2F to DL in the future, given their local context.

Theoretical Framework

Motivation — Achievement Goal Theory

This study draws on achievement goal theory, a motivation theory well-suited to the study of motivation in K-12 education (Linnenbrink & Pintrich, 2002; Utman, 1997). Achievement goal theory uses the construct of goal orientation to explain why and how students engage in academic undertakings. The theory identifies two primary goal orientations: mastery goals orientation and performance goals orientation. These different goal orientations are associated with different emotional experiences in relation to schooling and different ways of engaging in

school-based activities (Schunk et al., 2008). A mastery goal oriented individual strives to develop understanding and competence, to attain a sense of mastery (Ames, 1992). Mastery goals have been shown to be associated with wide range of positive cognitive, emotional, and behavioral outcomes, such as self-efficacy (Kaplan & Maehr, 1999) and, in science, enhanced conceptual understanding (Patrick & Yoon, 2010). A performance goal oriented individual strives to demonstrate competence to others, and are concerned with others' perceptions of their competence and with their ability relative to others (Ames, 1992), rather than with their own perception of their competence, as is typical of mastery oriented individuals.

Instructional Dimensions — TARGETS

According to achievement goal theory, different environments emphasize different achievement goals. Students' perceptions of these different goal emphases lead to the adoption of different achievement orientations (Kaplan & Maehr, 2007). A study by Vedder-Weiss and Fortus (2013) showed that during late elementary school and middle school, the two main environmental factors perceived by students and influencing their goal orientations in science are their parents and their science teachers. Science teachers can draw upon seven different instructional dimensions, represented by the acronym TARGETS (task, authority/autonomy, recognition, grouping, evaluation, time, and social interactions) to convey different goal emphases (Anderman et al., 2002). Teachers and educational organizations can employ these dimensions to support their students' adoption of the goals they wish to emphasize. Researchers can use these dimensions to identify the goals that underlie instruction. For example, a school that plans its schedule to allow students to work on projects continuously for several hours (time dimension) conveys a message that learning in this school is about developing mastery. On the other hand, a school that plans its schedule so that students can participate in marathon exercise-solving sessions in preparation for state or national high-stake tests conveys a message that learning in this school is about demonstrating performance. Similarly, science teachers that allow students to choose between several science projects (autonomy dimension) and make use of varied, challenging, high-order thinking assignments (task dimension) send a message that mastery is what is important to them, while other science teachers who publicly commend students who get the highest grades on exams (recognition dimension) send a message that performance is what counts (Maehr & Anderman, 1993).

Vedder-Weiss (2017) found that of all the TARGETS dimensions, instructional practices belonging to the task, authority/autonomy, and time dimensions are most likely to promote mastery goals. Mastery goals are desirable, as mentioned earlier, since they are associated with many positive educational outcomes. Thus, we focused in this study on these three TARGETS dimensions. Some of the features of instruction that are associated with these three dimensions are (Vedder-Weiss, 2017, p. 568): task — in which ways does the teacher organize learning activities in both psychological dimensions (e.g. high-order thinking, scaffolding, and situational

interest) and structural dimensions (e.g. content, procedures, products, and materials)? Autonomy — how much autonomy and responsibility for their learning are students given by their teacher? What influence do students have over the classroom activities? Time — is there time for students to ask questions and to follow up on these questions? How flexible is the scheduling of activities?

Culture and Motivation

Culture plays an important role in shaping motivation (Chen et al., 2005). It has been shown to influence the personal and contextual determinants of motivation (Liem, 2016) and to lead to specific motivational forces that drive learning and achievement (Meissel & Rubie-Davies, 2016). Comparative multi-cultural studies are an important approach to identifying the role culture plays in shaping motivation (Lam et al., 2016).

Research Questions

The research questions that guided this study were: (1) How did teachers' instructional practices, associated with 3 TARGETS dimensions, shift during the transition from F2F instruction to DL in the eyes of Chinese and Israeli students? (2) Which changes occurred to Chinese and Israeli students' goal orientations towards science following the shift from F2F instruction to DL? (3) What are the relations between the changes to instructional practices identified in RQ1 and the personal motivational shifts found in RQ2? (4) What can the similarities and the differences between the results for the Chinese and Israeli students inform us of local culture and conditions may have shaped the identified shifts and relations identified the three former research questions?

Methods

Participants

The participants were 8th grade Chinese students ($N = 1983$) from Beijing and from the center of Israel ($N = 308$) whose science teachers (A) had a reputation of fostering their students' motivation and learning of science, (B) who were teaching their classes in DL while the study was held, and (C) had taught the same classes in 7th grade, when instruction was still held F2F.

Instrument — Student Survey

An anonymous survey focusing on students' experiences and attitudes towards science learning in F2F and DL environments, their goal orientations towards science, and their perceptions of their science teachers' motivational practices was administered online during the COVID-19 pandemic, when instruction had moved to DL. The survey included 46 items describing various possible manifestations of several

Table 1 Constructs assessed by the student survey and example items

The construct	Example item
Mastery orientation	I do my work in (F2F/DL) science classes because it is important to me to improve my knowledge in science
Performance orientation	It is important to me that I look smart compared to others in my (F2F/DL) science classes
Task	The teacher gives us book assignments in (F2F/DL) science classes
Autonomy	Our science teacher lets us choose with whom to work during (F2F/DL) science classes
Time	Our teacher moves on to new subjects before I fully understand what was just taught in (F2F/DL) science classes

different constructs: mastery orientation in science, performance orientation in science, perceptions of teacher's use of task-oriented practices, of autonomy/authority practices, and of time practices. Each construct was represented by at least four different items. All items in the survey were based on a 1–5 Likert scale and were drawn from existing validated scales that have been used several times before with this age group (e.g. Vedder-Weiss & Fortus, 2012), repeatedly demonstrating excellent reliability. Example items are given in Table 1.

Analyses

Exploratory factor analysis (EFA) was performed on the Chinese and Israeli dataset separately. Common factors to both datasets were identified, named, and a student score for each construct was calculated. All factors were normally distributed. Paired *t*-tests were used to identify changes to each factor in each country. Multiple linear regression was used for each country to identify significant relations between the students' perceptions of their teachers' practices and their goal orientations in the different learning environments.

Results

Four common personal constructs were identified for both countries: (A) mastery orientation towards science, (B) performance orientation towards science, (C) engagement with science studies, and (D) the need to look smart compared to others. Six additional common constructs relating to students' perceptions of their teachers emerged: (A) teacher attentiveness with time (not moving on until students fully understand, allowing students to ask questions, etc.), (B) teacher use of various tasks, (C) teacher gives students autonomy, (D) teacher talks and the students need to listen, (E) teacher says there is not enough time, and (F) teachers' use of bookwork. The loading of the items on these constructs and their reliabilities (Cronbach alpha) is provided in an online appendix. The last construct, teachers' use of

Table 2 Constructs which declined in the shift between F2F instruction and DL, and in which country the decline occured

Construct which declined	Where	*t*-value	df	Effect size
Engagement	China	8.92	1982	0.23
Variety of tasks used by teachers	China	9.97	1982	0.22
Mastery orientation	Israel	6.07	307	0.35
Need to appear smart compared to others	Israel	5.63	307	0.32
Attentiveness of teachers	Israel	3.94	307	0.23
Autonomy given by teachers	Israel	3.94	307	0.23

p-value < 0.001 for all *t*-tests

workbook, had a low reliability (alpha Cronbach = 0.49) and was therefore not used in further analyses.

In the shift from F2F instruction to DL, significant declines, all with $p < 0.001$, were identified for the Chinese students in their engagement (effect size (ES) = 0.23) and in the variety of tasks used by their teachers (ES = 0.22). Significant declines were identified for the Israeli students in their mastery orientation (ES = 0.35), in their need to appear smart compared to others (ES = 0.32), in the attentiveness of their teachers (ES = 0.23), and in the autonomy given to them by their teachers (ES = 0.23). See Table 2.

In general, both before and after the transition to DL, Chinese students had significantly higher values on the following constructs than Israeli students: mastery orientation towards science (ES[1] = 0.34 for F2F and ES = 0.47 for DL), engagement (ES = 0.42, only before the transition to DL), need to look smarter than others (0.49 for F2F and 0.60 for DL), and in their perceptions of the teachers using a variety of tasks (ES = 0.64 for F2F and ES = 0.37 for DL), giving autonomy (ES = 0.63 for F2F and ES = 0.77 for DL), and saying there is not enough time (ES = 0.87 for F2F and ES = 0.65 for DL). See Table 3.

For both the Chinese and the Israeli students, mastery orientation was significantly predicted only by teacher attentiveness (for Chinese students: $\beta = 0.47$ for F2F and $\beta = 0.49$ for DL; for Israeli students: $\beta = 0.40$ for F2F and $\beta = 0.39$ for DL) and for the Chinese participants by the teacher relating things to daily life ($\beta = 0.43$ for F2F and $\beta = 0.39$ for DL), while mastery orientation predicted engagement (for Chinese students: $\beta = 0.34$ for F2F and $\beta = 0.18$ for DL; for Israeli students: $\beta = 0.39$ for F2F), all with $p < 0.001$. See Table 4.

Discussion and Implications

In general, the shift from F2F instruction to DL had a negative impact the Israeli participants' mastery orientation towards science. As a mastery orientation is considered beneficial, was found in this study to be a main predictor of engagement (see also

[1] The effect sizes given in the former paragraph and in Table 2 address the magnitudes of the changes that occurred in the transition for F2F instruction to DL. The effect sizes in the present paragraph address the magnitude of the differences between the Chinese and the Israeli students.

Table 3 Constructs which had higher values in China than in Israel

Construct	F2F/DL	*t*-value	Effect size
Mastery orientation	F2F	5.48	0.34
Engagement		8.91	0.42
Need to appear smart compared to others		8.04	0.49
Variety of tasks used by teachers		10.4	0.64
Autonomy given by teachers		10.3	0.63
Teachers say there's not enough time		14.2	0.87
Mastery orientation	DL	7.66	0.47
Need to appear smart compared to others		9.81	0.60
Variety of tasks used by teachers		6.10	0.37
Autonomy given by teachers		12.6	0.77
Teachers say there's not enough time		10.6	0.65

$p < 0.001$ and df = 2289 for all *t*-tests

Table 4 The constructs predicting mastery orientation and engagement in Chinese and Israeli students

Country	Predicting construct	F2F/DL	Mastery orientation			Engagement		
			beta	df	*t*-value	beta	df	*t*-value
China	Teacher attentiveness	F2F	0.47	1982	21.7	-	-	-
		DL	0.49	1982	22.7	-	-	-
	Teacher relating things to daily life	F2F	0.17	1982	8.03	-	-	-
		DL	0.18	1982	8.28	-	-	-
	Mastery orientation	F2F	-	-	-	0.34	1982	16.3
		DL	-	-	-	0.39	1982	17.6
Israel	Teacher attentiveness	F2F	0.40	307	7.67	-	-	-
		DL	0.39	307	7.33	-	-	-
	Mastery orientation	F2F	-	-	-	0.39	307	7.43

Vedder-Weiss & Fortus, 2013), and is positively associated with many other desirable learning characteristics, such as effort and persistence (Elliot et al., 1999), self-regulation (Pintrich, 2000), and transfer (Bereby-Meyer & Kaplan, 2005), this decline is worrisome. On the other hand, Israeli students' mastery orientation towards science and towards academic learning in general tend to decrease during adolescence (Vedder-Weiss & Fortus, 2011), so it is not clear whether the decline identified in this study is exceptional. The Chinese participants' mastery orientation also decreased during the transition to DL, but not in a statistically significantly manner.

On the other hand, there was a significant decline in the Chinese participants' engagement with science. This is very concerning, since without engagement, little systematic learning will occur (Irvin et al., 2007).

Compared to the Israeli students, the Chinese students were more mastery oriented and felt the need to appear smarter than their peers. This may be due to the relative competitiveness of the Chinese educational system, where students compete for places

at the top high schools and then at the universities (e.g. Yin & Buck, 2015). In Israel, the system is less competitive, students can typically choose in which discipline they want to major (Israel Ministry of Education, 2022), they tend to go to local schools, and the percent of the population that obtains a postsecondary degree is very high — 47% (Organization for Economic Cooperation and Development [OECD], 2017).

The Chinese participants perceived their teachers as providing more autonomy, using a wider variety of tasks, and saying that there is not enough time more than the Israeli participants did. Since we do not have an objective measure of what the teachers actually did in their classes, we cannot know whether these perceptions indeed reflected reality or whether they were an indication of students differing expectations from their teachers. This is an issue that faces all cross-cultural comparisons. If, for example, in one culture homework is typically never given, but then a few teachers occasionally give homework, their students may feel that they are being overburdened. If in another culture homework is typically given after each lesson, but then one teacher does not give homework a few times, the students may feel like they are on vacation. What matters often is what students see their teachers doing relative to what is perceived to be the norm in their culture. Thus, it is impossible to know if Israeli science teachers actually give their students less autonomy than their Chinese counterparts. It could be that providing autonomy to students in China is relatively rare in comparison with Israel, but when it is provided in China, it is subjectively highly rated by the students, unlike in Israel where they take it for granted. Note that the teachers in this study were reputed to be good motivators of their students, and since providing autonomy is an important way for teachers to motivate their students (Vedder-Weiss, 2017), we expect that the participating teachers all provided their students with significant autonomy.

Of the three teaching dimensions from the TARGETS framework (Anderman & Midgley, 2002) that were investigated in this study (task, autonomy/authority, and time), time proved to be the most significant predictor of student mastery orientation. Teachers' willingness to provide their students with plenty of time to ask questions until they felt that they deeply understood the material being learned before moving on was a major predictor of students' mastery orientation towards science in both F2F instruction and DL, for students in both countries. We understand these relations as follows: a student who is driven by mastery goals wants to develop a sense of deep understanding, of mastery. When the teacher moves on to a new topic before this sense is not reached, when the student does not have the opportunity to ask questions that may help clarify and organize ideas, the student is likely to feel frustrated. When this reoccurs several times, in order to prevent the repeated frustration, the students may change their expectations the development of the sense of mastery that comes with deep understanding, and with time become less mastery oriented. Indeed, Sørum et al. (2021) found that also college students find it more difficult to ask question in DL and then to be less active in DL than in F2F instruction. This finding is in line with past research that has indicated that science teachers' time-related practices are central to shaping students' goal orientations (Vedder-Weiss, 2017).

Interestingly, despite significant cultural differences between the two countries and differences in the behavior of several motivational constructs, two central

relationships of great importance behaved similarly in both countries and maintained their significance during the shift from F2F instruction to DL: the relationship between teachers' attentiveness to students' need for time to understand and the students' mastery orientation, and the relationship between students' mastery orientation and their engagement with science learning. Teachers' attentiveness to students' questions and to their need to feel they fully understand before moving on is a crucial instructional practice that is a strong predictor of students' mastery orientation. However, the emphasis on this practice, as perceived by both Chinese and Israeli students, declined during the shift from F2F instruction to DL. Either the teachers actually provided less time for students to ask questions and develop understanding or technological issue may have prevented the students from asking questions as they would have in F2F instruction. Or perhaps technological issues made it more difficult for the teachers to identify that their students still did not fully understand, and being misinformed of the actual situation, they moved on. Whatever the reason, the students perceived this as a decline in their teachers' attentiveness to their need to understand, and this decline appears to have led to a decline in the students' mastery orientation towards science. And when students' mastery orientation declined, so did their engagement with science learning, though not always significantly. Since these declines occurred in both countries, despite significant cultural differences, they are possibly driven more by the inherent affordances and constraints of each learning environment than by cultural forces. If this is the case, we expect that this particular instructional practice, attentiveness to students' need to ask question and develop understanding, declined in many different countries and cultures and had similar impact on students' mastery orientation towards science and their engagement with science learning. Teachers and instructional designers everywhere should be aware of this and consider changes to lesson design and the technological environment supporting DL to minimize this negative impact.

During the COVID-19 pandemic, teachers were expected to be prepared for any scenario, F2F or DL. Hopefully, there will no need in the future to return to full DL in China, Israel, or any country, but in any case, the results of this study could be used to inform science teachers everywhere of the importance of being attentive to their students' needs to ask questions and feel like they are developing understanding, both F2F instruction and DL.

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Data Availability The dataset generated during and analyzed during the current study is available from the corresponding author on reasonable request.

Declarations

Conflict of Interest The authors declare no competing interests.

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