International Journal of Teaching and Learning in Higher Education 2020, Volume 32, Number 2, 190-200
http://www.isetl.org/ijtlhe/ ISSN 1812-9129

The Efficacy of Guided Inquiry versus Video in an Online Setting: Do Students Characteristics Matter?

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We experimentally assessed the efficacy of two online instructional methods, guided inquiry and video, on learning and conceptual change, while also examining the relationship of student characteristics to these outcomes. Results indicate an interaction between mindset and instructional method for learning; additional learner characteristics may also influence the efficacy of these instructional methods. Overall, misconceptions were resistant to change. Implications for online instruction and future directions for research are explored.

Online courses are becoming increasingly common at universities as technology continues to expand educational possibilities for remote course delivery (Robinson & Hullinger, 2008). However, engaging students so that they deeply learn course material in an online setting can be particularly challenging due to its remote and asynchronous nature (Thormann & Zimmerman, 2012). In addition, it is at times necessary to restructure students' erroneous beliefs about subject matter (Vosniadou, 2007); however, doing so can be difficult because some erroneous beliefs are resistant to change, even when corrective information is presented (Lethaby & Harries, 2016; Pasquinelli, 2012). Because of the aforementioned challenges with online courses, this belief change process may be especially difficult to accomplish in the online instructional setting.

One promising instructional method to address these challenges is Guided Inquiry (GI). When embedded in on-ground settings as a significant piece of Process-Oriented Guided-Inquiry Learning (POGIL), this method has demonstrated fairly robust success for student learning and engagement (e.g., Brown, 2010; Eberlein et al., 2008). Although some of the elements essential to the full POGIL method can be more challenging to implement online, most notably its synchronous group interactions, the structure of guided inquiry questions may be more effective for engagement, learning, and belief change in online instruction than static information delivery methods such as video lectures or reading assignments. GI questions can guide students to think with increasing complexity about course concepts, which helps students more effectively rehearse and code information to put into long-term memory (Willingham, 2009). In addition, GI questions can be structured to help students become aware of any inconsistencies between their existing beliefs and scientific evidence, a necessary step toward belief restructuring (Vosniadou, 2007).

Although the use of GI for online learning holds promise, individual differences among students may play a role in their approach to learning online. In particular, factors such as mindset, academic self-efficacy, and academic entitlement may relate to students' approach toward instructional methods, such as whether students engage in GI at levels that result in learning and belief change. The purpose of our study, therefore, was to compare the efficacy of GI to a more standard online instructional method (video) for outcomes of learning, belief change, and engagement, as well as to examine the relationship of student factors to these outcomes in each condition.

Instructional Challenges

Beyond learning new information and skills in a class, students may, at times, have beliefs about aspects in the field that need adjustment or reversal. Also known as conceptual change, belief adjustments occur when naïve theories (or "misconceptions"; Alexander, Murphy, & Sun, 2018) of the learner are brought to light and inconsistencies between the naïve theory and the scientific theory are clearly presented (Vosniadou, 2007). Sometimes, however, misconceptions are perpetuated by misinformation in the field. For example, in education, several "neuromyths," based on erroneous interpretations of neuroscience, continue to be endorsed among professionals (Lethaby & Harries, 2016). Certain of these neuromyths, such as the theory that individuals have specific learning styles (e.g., visual-auditory-kinesthetic, or "VAK") or that listening to classical music has a positive impact on child development (known as the "Mozart effect"), have even permeated into popular belief, sometimes via commercial exploitation or public policy (Pasquinelli, 2012). Misconceptions can be resistant to change, even when robust scientific information debunking the myths is available, possibly because of biases in thinking about the myths (Pasquinelli, 2012) or epistemological stances that result in valuation of sources of knowledge that may be less reliable (Alexander, Murphy, & Sun, 2018). These beliefs, however, can be harmful to hold, because time and resources are put toward ineffective practices rather than those that work (Pasquinelli, 2012). It is therefore important that when college instructors address

conceptual change among their students, often with limited time to dedicate to any one topic, they use the most impactful instructional methods possible.

Effective instructional methods for student learning and conceptual change require careful consideration in any educational environment, but perhaps even more so in the online classroom. Because an online learning environment often lacks the synchronicity and immediate presence of on-ground classes (Ragan, 2007), it is integral to find ways to keep students actively engaged in the learning process. Active learning is brought about when students must do something other than merely watch, listen, or take notes; instead, they are asked to engage in activities such as observation, reflection, or discussion with others (Felder & Brent, 2009). Not only do active learning methods relate to positive learning outcomes (Prince, 2004), but in the online environment, they are tied to increased student engagement, a key to online learners' satisfaction (Dziuban et al., n.d.).

Guided inquiry (GI) is an active learning method that can take two forms. In the first form, students' own inquiry and exploration of a topic is structured and encouraged by the instructor (e.g., FitzGerald, 2011). In the second form, which is embedded in the POGIL format, learners answer a series of instructor-posed questions, often based around models or data, that require them to think critically, problem-solve, and construct their own understandings (Farrell, Moog, & Spencer, 1999). The questions guide students through a learning cycle of exploration, concept invention, and application (Eberlein et al., 2008); this form of GI can thus be considered constructivistic in nature (Farrell et al., 1999). GI in this format has been successfully employed in the on-ground, higher education classroom setting, demonstrating increased achievement, engagement, and positive attitude toward the learning environment (e.g., Brown, 2010; Chase, Pakhira, & Stains, 2013).

The online environment presents challenges to using the entire POGIL format; in particular, its often-asynchronous nature makes the cooperative groups aspect of POGIL more difficult, although some preliminary exploration of using the POGIL format online indicates favorable results (Trevathan & Myers, 2013). The use of only the GI questions, however, may be more easily applied in the online setting, and may still confer many of the positive outcomes observed in the on-ground settings. Not only can GI questions assist students in constructing deep understandings of new course material (Farrell et al., 1999), but they can also be constructed in a way that helps learners to contrast their misconceptions against scientific evidence.

The active approach of GI can be contrasted with a common instructional method for online classes: the video. Videos can be used in many dynamic ways, and there is evidence that the use of videos, as compared to text-based information, results in better student learning (Yousef, Chatti, & Schroeder, 2014). Further, presenting information visually as well as through linguistic channels in a video is supported by dual code theory, which suggests that information presented both verbally and nonverbally (i.e., with imagery) is more likely to be learned (Paivio, 1991). Videos of the instructor presenting information may also add social presence within the course (Bialowas & Steimel, 2019).

However, use of video absent any additional pedagogical methods is not advised (Chuang & Rosenbusch, 2005). Such a method reflects a transmissional model of instruction (Boulton-Lewis, Smith, McCrindle, Burnett, & Campbell, 2001), similar to that of mainly lecture-based classrooms. That is, learners presented with a video for exposure to new information, without any additional activities to utilize that information, remain passive in a unidirectional process. This use of videos in online instruction, which may be particularly common among instructors with a knowledge transmission conception of learning (Boulton-Lewis et al., 2001), may not have as strong an impact on student learning or conceptual change as active instructional methods, such as GI.

Learner Characteristics

Student approach to various online instructional methods may be impacted by personal characteristics, especially those that are related to effort and persistence (Kerr, Rynearson, & Kerr, 2006). In particular, mindset, academic self-efficacy, and academic entitlement have demonstrated links with features such as effort and engagement, which are key for positive outcomes using active learning methods in traditional settings (Cavanagh et al., 2018; Greenberger, Lessard, Chen, & Farruggia, 2008; Schunk, 1991; Vallade, Martin, & Weber, 2014). These student characteristics thus may be associated with student approach to active versus more traditional (e.g., video viewing) online instructional methods.

Mindset is a cognitive framework that is concerned with how people perceive their intelligence (Dweck, 2006). Two mindsets, growth mindset and fixed mindset, are determined by the students' beliefs about themselves and their abilities to learn (Dweck, Walton, & Cohen, 2014). Students who believe that learning and intelligence are unchanging have fixed mindsets; those who see intelligence and learning as malleable and able to be improved have growth mindsets (Dweck, 2006). A notable difference between mindsets is the perception of effort: Those with a fixed mindset see effort as evidence of reaching one's intellectual limits, and thus they avoid effortful activities. Those with growth mindsets, however, see effort as necessary to intellectual growth and will therefore embrace effortful challenges (Blackwell, Trzesniewski, & Dweck, 2007). Because answering GI questions becomes increasingly effortful as learners are

led to make comparisons or draw implications, students' mindsets may play an important role in the efficacy of GI, particularly in an online setting where synchronous, collaborative peer assistance to distribute the effort load is less likely to be available.

Academic self-efficacy is a person's judgment of his or her competence when approaching academic activities (Schunk, 1991), and it is hypothesized to influence attitudes toward challenges, effort, and persistence in related activities (Bandura, 1977). Higher academic self-efficacy is associated with engagement in activities that are believed will lead to learning, as well as greater mental effort, motivation, and task persistence (Schunk, 1991). As such, students with higher academic self-efficacy, much like those with growth mindsets, may more fully engage in GI activities.

In contrast to the willing effort associated with growth mindset and academic self-efficacy, academic entitlement is the belief that one is owed success in an academic setting despite limited effort (Greenberger et al., 2008). More prevalent in men than women, academic entitlement has demonstrated a negative association with an enjoyment of effortful cognitive activities (Chowning & Campbell, 2009). Therefore, those with greater academic entitlement may refrain from fully engaging in progressively challenging GI activities.

Study Questions and Predictions

The purpose of our study is to compare the efficacy of two online instructional methods, GI and video information delivery, using instruction about a common neuromyth, the VAK learning styles. Our research questions include: What is the efficacy of the methods on both learning and conceptual change, and are there differential effects? Further, do mindset, academic self-efficacy, and academic entitlement relate to differences in the efficacy of each method? We predict that, overall, the GI will result in better learning and belief change than the video, in part because of its active and constructivist nature (Farrell et al., 1999). We also predict, based upon our literature review above, that growth mindset and academic self-efficacy will be associated with increased learning and subsequent belief change, particularly in the GI condition, whereas academic entitlement will be associated with decreased learning and belief change, particularly in the GI condition.

Methods

Participants and Procedure

Participants were 142 undergraduate college students from a Southeastern university, ranging in age from 18 to "over 25," with 78% of participants between the ages of 18-21. Seventy-five percent (n = 107) of the participants were women, and the majority of participants (76.8%; n = 109) were Caucasian, 3.5% (n = 5) were African-American, 6.3% (n = 9) were Asian, 2.1% (n = 3) were Hispanic, 2.8% were Biracial (n=4) and 8.5% (n = 12) identified as "other." Fifty-eight percent of participants (n = 82) were enrolled as freshmen or sophomores.

Participants for our IRB-approved study were recruited through an online system where individuals could review all open studies and then anonymously and voluntarily sign up. Respondents received course participation credit (applied to any course associated with the recruitment system) for completing the study.

Upon electing to participate in the study, participants first confirmed their informed consent, and then completed an introductory survey, which included questions about demographics, mindset, academic self-efficacy, academic entitlement, and a learning styles knowledge and belief pretest. Participants were then sent an email indicating their access into a fictitious online course using the university's online course management system, Desire 2 Learn (D2L). Within the course shell, participants were randomly assigned by D2L to either the Video or GI condition and completed the associated instructional task. Participants were blind to the nature of either instructional task and could only access the one to which they were randomly assigned. Following completion of the task, participants were provided a link to another survey, which included knowledge and belief post-tests and questions about perceived engagement and effort. The approximate time for completion of this portion of the study was one hour, and participants were recruited and completed the study in multiple waves across the course of approximately 6 months.

Approximately two weeks after completion of the post-test, participants were e-mailed an invitation to participate in a follow-up survey for additional study participation credit; the follow-up survey re-assessed content knowledge and beliefs. However, because the number of participants who completed the follow-up survey was significantly diminished (N = 51) and only one participant for one of the condition x mindset cells completed it, these data were not examined in the outcome analyses. The follow-up learning styles knowledge test data was used, however, to examine test-retest reliability for that instrument.

Instructional Intervention

Within the online course setting, participants completed a learning activity about learning styles. The activity was offered to participants in one of two possible formats, assigned randomly: video or guided inquiry. For the video condition, participants watched a 7-minute, well-edited and produced video which explains the premises of learning styles theories, the state of current research on learning styles (which largely fails to support

them), and the reasons people tend to maintain belief in learning styles despite lack of empirical support (Willingham, 2008). This video was created by Dr. Daniel Willingham and posted for public use on the Internet; Dr. Willingham gave permission for the video to be used in this study. Participants were instructed to watch the video in its entirety. They completed no other learning tasks associated with the video.

For the guided inquiry condition, participants were introduced through text information, graphs, and other visuals to the same information about learning styles as was introduced in the video. Information was provided in brief "models", often in the form of a chart or graphic; following each informational model, participants responded to open-ended questions that guided their exploration and explanation of the information provided, occasionally also requesting that participants provide implications of the information (see Appendix for sample). Participants were instructed to (with a few exceptions) avoid overly brief responses, and to instead support their reasoning in one to two sentences. Participants were also told that it was important that they complete the activity with full effort by answering each item completely and that they complete the activity in one sitting.

Measures

Mindset was measured using a three-item Mindset Scale created by Dweck and Henderson (1989). Participants rate their beliefs about the fixed or malleable nature of intelligence; higher scores indicate endorsement of malleable intelligence. The measure has previously demonstrated good reliability (α=.94 - .98; Hong, Chiu, Dweck, Lin, & Wan, 1999) and was excellent in ours, α=.91.

The Academic Self-Efficacy (ASE) scale consists of 12 items for college students created per Bandura's guidelines (Bandura, 2006); some were developed by Havens (2008) and others created for this study. Participants rate their confidence in their abilities to engage in academic planning, studying, and learning on a 6-point Likert scale, where higher ratings indicate greater confidence. Reliability of Havens' (2008) version of the scale was excellent (α = .90); for our modified version of the scale, reliability was also excellent, α=.93.

The Academic Entitlement (AE; Greenberger et al., 2008) scale consists of 15 items which measure respondents' agreement on a 6-point Likert scale with statements reflecting their sense of entitlement to positive treatment despite limited academic efforts. Higher scores indicate greater levels of AE. The original internal consistency for the AE scale was very strong (α = .87; Greenberger et al., 2008), as it was in our study, α=.88.

Out of concern for participants trying to be viewed favorably for either the personal characteristics measures or the knowledge/belief measures, social desirability was assessed for use as a covariate. Social desirability was measured using the 20-item short form of the Marlowe-Crowne Social Desirability Scale (M-C 20; Strahan & Gerbasi, 1972). Reliability coefficients for the M-C 20 have previously ranged from .71 to .87 for various populations (Ballard, 1992; Fraboni & Cooper, 1989; Strahan & Gerbasi, 1972); for our study, reliability was acceptable, α = .80.

Participants' accurate knowledge of the premises and research findings regarding learning styles theory was objectively assessed using the 7-item Learning Styles Knowledge Test which was created for this study. Because items were scored as correct/incorrect and participant knowledge varied, internal consistency of the test was difficult to assess. However, test-retest reliability using the two post-intervention applications of the test (post-test, $N = 142$, and follow-up test, $N = 51$) indicated a very strong and significant correlation, $r = 0.65$, $p<.001$, suggesting good test reliability.

Participants' beliefs about learning styles (i.e., endorsement vs. non-endorsement of learning styles theory) was assessed in three ways. First, a 6-item scale, created for this study, asks participants to rate their level of agreement, on a 6-point Likert scale, with statements endorsing learning styles; higher scores indicate greater endorsement. For this Learning Styles Belief Scale, pre-test internal consistency was poor (α = 0.53); however, after the learning activity, which presumably consolidated participants' understanding about learning styles, the same scale exhibited dramatically improved reliability, α = 0.84.

An additional, single belief item asked participants to select the answer that best described them from a drop-down menu: "I am a visual learner; I am an auditory learner; I am a kinesthetic learner; I do not believe in 'types' of learners." Endorsement of one of the first 3 choices was taken as a single-item indicator of belief in learning styles; endorsement of the 4th choice was taken as indication of disbelief. Finally, as an open-ended assessment of belief in learning styles, a written response was solicited from participants, asking them to, "Please write 1-2 sentences about what you believe regarding the idea of learning styles." Responses were used to provide qualitative insights for our other, quantitative findings.

Lacking the necessary elements required for existing measures (such as multiple, varied educational tasks over time; Veiga, Reeve, Wentzel, & Robu, 2014), engagement and effort for our study were each assessed using a single, self-reported item. For engagement, participants were asked, "How much were you engaged in the instructional task (that you completed in D2L)?" Participants responded on a 5-point Likert scale (Not at all; Minimally; Somewhat; Mostly; Very much). For effort, participants were asked, "How much effort did you give toward the task (i.e., follow instructions with care)?" Ratings for this item were also on a 5-point scale (None; Minimal; Some; Most; All).

Analyses

Relationships among continuous study variables were assessed using partial correlations, controlling for social desirability. For these correlations, mindset average scores were utilized as a continuous variable. For between-groups analyses, participants were categorized into fixed or growth mindsets, using instructions from Dweck and Henderson (1989). Thus, participants whose mean score on the mindset items was between 1 and 3 were categorized as having a fixed mindset, and those whose mean score was between 4 and 6 were categorized as having a growth mindset. Those with scores between 3.1 and 3.9 were considered to have no definitive mindset and were, per Dweck and Henderson (1989), excluded from group comparisons that included mindset (n = 17; 10 from video condition and 7 from GI condition). To examine the interaction of condition by mindset on engagement, effort, learning, and beliefs, a 2x2 multivariate analysis of covariance, controlling for the effects of social desirability, was conducted using post-test data. Data for the categorical, drop-down belief item was assessed using chi-square analyses.

Results

Examination of the partial correlations (Table 1) indicates that, as expected, post-test knowledge scores were significantly and negatively correlated with post-test belief scores, r = -.34, p<.01. However, pre-test belief scores and post-test belief scores were significantly and positively related, r = .18, p<.05.

Interesting correlation patterns emerged regarding approaches and attitudes toward learning. A characteristic considered to be beneficial, academic self-efficacy, shared a positive correlation with a belief in learning styles before the learning activity (i.e., at pre-test; r = .24, p<.01), but after the learning activity, that correlation was near zero. Examination of belief post-test correlations with academic self-efficacy across conditions indicated that the associations within each condition were very similar. In contrast, academic entitlement (considered a non-beneficial attitude; Greenberger et al., 2008) had no significant correlation with either knowledge or beliefs about learning styles before the learning activity, but that relationship became significant and negative for the knowledge post-test (r = -.26, p<.01) and significant and positive for the belief post-test (r = .29, p<.01). Although this pattern of correlations was consistent in both conditions, the strength of the associations was much greater in the guided inquiry condition (r = -.34, p=.01 for knowledge post-test and r = .42, p<.01 for belief post-test; df = 56) than in the video condition (r = -.14, p>.05 for knowledge post-test and r = .24, p<.05 for belief post-test; df = 69). Notably, academic entitlement was significantly and negatively related to both academic self-efficacy (r = -.21, p=.01) and growth mindset (r = -.32, p<.01).

A 2 (condition) x 2 (mindset) MANCOVA, using social desirability as a covariate, was conducted for the post-intervention applications of the Learning Styles Knowledge Test (post-intervention application) and the Learning Styles Belief Survey, the difference in pretest to post-test mean scores on the Knowledge test and Belief survey, and the engagement and effort self-reported ratings. Box's M and tests of normality were conducted and assumptions were met, mitigating concerns regarding the interpretation of results given the imbalance of ns across cells. Analyses indicated no main effects for either condition or mindset. However, significant interactions between condition and mindset were found for Knowledge post-test scores (F[1, 119] = 5.60, p<.05), engagement (F[1, 119] = 4.75, p<.05), and effort (F[1, 119] = 4.01, p<.05). The interaction between condition and mindset for pretest to post-test differences in Knowledge approached, but did not meet, significance, F(1, 119) = 2.47, p = .12. Examination of the adjusted mean scores (Table 2) indicates that for all significant interactions, those in the video condition who had a fixed mindset scored higher than those with a growth mindset, whereas in the GI condition, those with a growth mindset scored higher than those with a fixed mindset.

Examination of endorsement of the drop-down belief item about learning styles indicates that, at pretest, all but 3 of the n=124 participants, regardless of mindset, endorsed a belief in learning styles. For the post-test belief endorsements, a two-way group-independence chi-square was performed to examine the relationship between condition and mindset. The chi-square statistic was not significant for those endorsing belief in learning styles, χ^2 = 1.38, df = 1, p = .24. However, group differences were significant for those endorsing disbelief in learning styles at post-test, χ^2 = 4.63, df = 1, p=.03, with an effect size of ϕ= 0.37, indicating a significant relationship between condition and mindset for disbelief in learning styles after the instructional intervention, such that participants with a growth mindset were more likely to not believe in learning styles when in the GI condition than in the video condition, whereas the opposite was true for those with a fixed mindset (Figure 1).

Discussion

Contrary to our predictions, we found no main effects for instructional method. Learning and belief change were not significantly different for participants in the GI condition as compared to the video condition. Instead, it appears that efficacy of the instructional methods, particularly on learning, depends on student characteristics.

Participant mindset interacted with instructional method such that those with a fixed mindset had better learning, engagement, and effort in the video condition

Table 1
Partial Correlations of Study Variables

Study Variables	1	2	3	4	5	6	7	8	9
1. Knowledge Pretest	-								
2. Knowledge Posttest	0.19*	-							
3. Belief Pre-Survey	-0.16	0.05	-						
4. Belief Post-Survey	0.01	-0.34**	0.18*	-					
5. Engagement	0.04	0.25**	0.11	-0.22**	-				
6. Effort	0.04	0.23**	0.12	-0.19*	0.70**	-			
7. Mindset	-0.01	0.02	0.13	0.01	0.11	0.08	-		
8. Academic Self-Efficacy	-0.04	0.14	0.24**	-0.02	0.24**	0.18*	0.07	-	
9. Academic Entitlement	-0.04	-0.26**	-0.08	0.29**	-0.01	-0.07	-0.32**	-0.21**	-

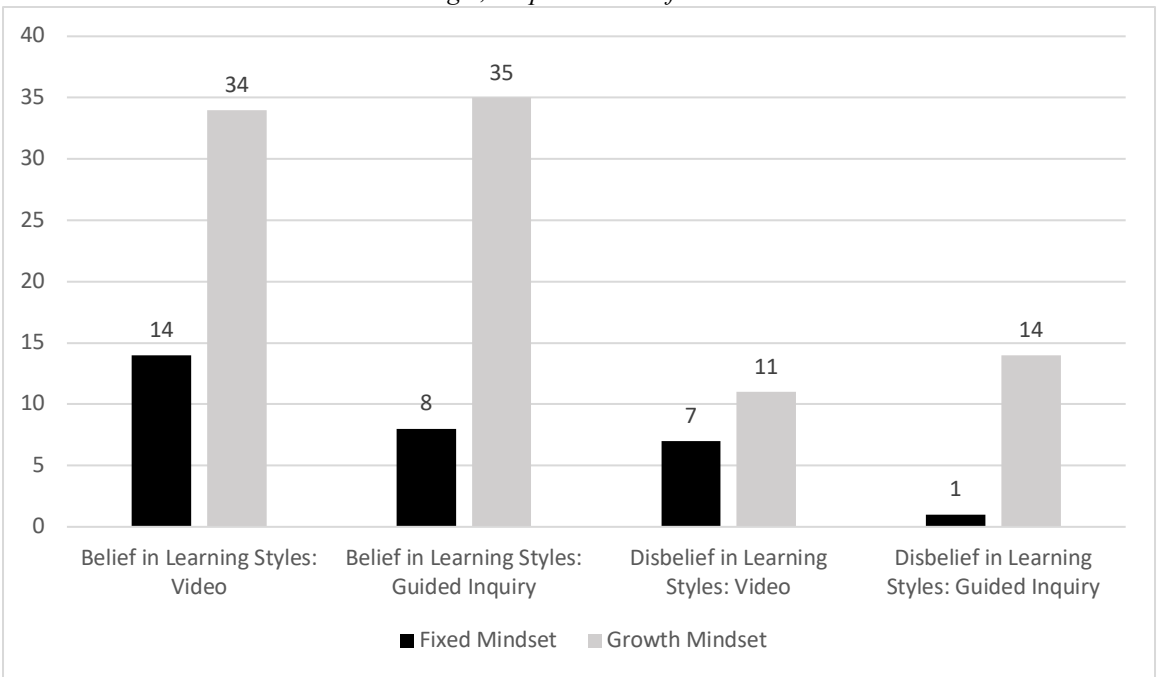
Note: Correlations controlling for Social Desirability. *$p \leq .05$; **$p \leq .01$; $df = 133$.

Table 2
Descriptive Statistics of Study Outcome Measures by Condition and Mindset

		Outcome Measures											
		Knowledge Posttest		Knowledge Pretest to Posttest Difference		Belief Post-Survey		Belief Pre-Survey to Post-Survey Difference		Engagement		Effort	
Condition	Mindset	*M* (*SD*)	Adj. *M*	*M* (*SD*)	Adj. *M*	*M* (*SD*)	Adj. *M*	*M* (*SD*)	Adj. *M*	*M* (*SD*)	Adj. *M*	*M* (*SD*)	Adj. *M*
Video	Fixed Mindset (*n*=21)	4.62 (1.20)	4.62	1.52 (0.98)	1.52	3.30 (1.26)	3.30	-1.09 (1.46)	-1.09	3.76 (0.62)	3.76	3.86 (0.91)	3.86
	Growth Mindset (*n*=45)	4.36 (1.19)	4.35	1.31 (1.61)	1.30	3.60 (1.02)	3.59	-1.06 (1.21)	-1.06	3.44 (0.94)	3.45	3.69 (0.92)	3.69
Guided Inquiry	Fixed Mindset (*n*=9)	4.00 (1.66)	3.94	1.00 (2.60)	0.94	3.33 (0.78)	3.31	-0.93 (1.42)	-0.94	3.44 (1.13)	3.46	3.44 (1.24)	3.46
	Growth Mindset (*n*=49)	4.90 (1.08)	4.92	1.82 (1.58)	1.84	3.30 (1.12)	3.30	-1.30 (1.00)	-1.30	4.04 (0.94)	4.04	4.12 (0.83)	4.12

Note: Adjusted means based upon Social Desirability = 0.52.

Figure 1
Frequency chart for belief/disbelief in learning styles at post-test by condition and mindset. Measured using the single, drop-down belief item.



as opposed to the GI condition, whereas those with a growth mindset indicated greater learning, engagement, and effort with the GI than the video. These findings corroborate a body of empirical findings indicating that those with growth mindsets are more academically tenacious and view effort as a virtue, whereas those with fixed mindsets avoid expenditure of effort, as it suggests to them that they may be at the limits of their intellectual capacity (Dweck et al., 2014). However, it is interesting to note that those with a growth mindset learned less well in the video condition – a condition in which those with a fixed mindset did better. These findings may indicate that students with growth mindsets prefer, and learn better from, effortful learning activities, whereas those with fixed mindsets will learn more with instructional methods that require less effort, perhaps because such activities do not threaten their intellectual self-perception (Blackwell et al., 2007).

Of interest, our findings suggest that academic entitlement may be associated with resistance toward instructional methods, particularly those that require greater effort (such as our GI). For both instructional methods, academic entitlement was negatively correlated with knowledge gains and positively related to post-instructional belief endorsements of learning styles; these correlations were more pronounced in the GI condition. Because these associations were non-significant prior to the learning condition, it appears that, for those with greater academic entitlement, simply participating in either instructional method was more likely to lead to outcomes antithetical to the purpose of the instruction. Although this relationship and its possible mediators require further exploration, academic entitlement has been noted as a key characteristic of millennial students (Goldman & Martin, 2016), and these students have also been characterized as resistant to authoritarian policies, which can impact student-instructor rapport (Frey & Tatum, 2016) and perhaps, by extension, academic success.

Academic self-efficacy did not relate to post-instructional knowledge, but it did seem to be associated with some belief change in the desired direction. That is, a significant, positive correlation between academic self-efficacy and belief in learning styles that existed pre-instruction was nullified after instruction; there were no notable differences in the strengths of these changes between instructional methods. Our findings suggest the possibility that those with greater academic self-efficacy may be more open to learning information that contradicts misconceptions and to gradually adjusting their beliefs. Research, although not conclusive, indicates that academic self-efficacy is related to the personality construct of Openness to Experience, which is associated with curiosity and critical thinking, and thus also associated with positive academic performance (McIlroy, Poole, Ursavas, & Moriarty, 2015). However, since our results indicate that the beginning of belief change, but not greater learning, is associated with

academic self-efficacy, more exploration into the complexities of these relationships is warranted.

Overall, the results of our study suggest that belief change was more difficult to achieve, despite improvements in learning. Even when the instructional method and mindset were optimally paired, those groups did not differ on the multi-item measure of beliefs about learning styles. We did find mild evidence that those with growth mindsets in the GI condition were more likely to endorse non-belief in learning styles on a single-item measure than those in the video condition (the opposite was true for those with fixed mindsets). Thus, we may again be seeing some evidence that mindset and instructional method interact such that those with growth mindsets begin to correct misconceptions with effortful course activities, whereas those with fixed mindsets do better with less effortful activities.

Nevertheless, it appears that a single dose of instruction using either method is not strong enough to strongly affect belief change. The persistence of misconceptions that we witnessed may be due in part to their relationship with participants' identity, as those who hold misconceptions related to their self-identities are more likely to resist new information which contradicts them (Nyhan & Reifler, 2018). In their open-ended responses, some participant statements supported this possibility:

- "Although after watching the video I still believe in types of learning. I am a visual learner."
- "Personally, I am a visual learner, more hands-on learner."

In addition to self-identity increasing resistance to belief change, certain epistemological stances, and in particular a foundationalist perspective, may not be compatible with many academic domains (Alexander et al., 2018). Foundationalists prefer reliance on intuitive beliefs rather than scientific evidence (Alexander et al., 2018), and we saw corroborating evidence of this perspective in some participant responses:

- "Of course people learn better if the teaching is done in their own learning style. Research proving this or not is irrelevant in this case."
- "I believe that students do have different learning styles regardless of a lack of experiments [supporting them]."

These types of statements corroborate Kahneman's (2011) observations that once a theory is personally accepted and integrated into one's thinking, it becomes very difficult to acknowledge its flaws. Thus, although GI is a promising start to promoting belief change, it may need to be tested and built into a non-threatening or supportive atmosphere that includes interpersonal dialogue and gradual instruction about building better habits of mind (Alexander et al., 2018).

Our study provides useful information about the efficacy of GI and videos in the online class setting; however, its limitations include its fictitious class setting and one-time learning event, such that participants may not have been as invested as they might be in a higher-stakes class environment, nor as impacted by the instructional method as they might have been over an entire term. Relatedly, participants were not solely Education students, and thus may have been less interested in learning, or changing views about, the subject matter. Further, our sample had limited ethnic diversity, reducing the generalizability of our results. Finally, our assessments of engagement and effort are not robust; they give us insight into possible outcomes but should be replicated with more reliable measures before reaching conclusions. Similarly, our multi-item measure of beliefs had poor pre-test reliability, making the degree of belief change from pre-test to post-test difficult to truly ascertain. Future belief assessments may benefit from a brief introduction to the topic in question before assessing initial beliefs in order to increase reliability of pre-test measurement.

Despite these limitations, our study provides useful implications for online instruction. In particular, our results suggest that choice remains important for learners so they can select the instructional method that best aligns with their attitudes toward effort. Autonomy, supported via choices, is considered elemental to motivation (Ryan & Deci, 2000), and our results provide further insight into why student choice is important in instruction. Additionally, mindset change is possible (Dweck et al., 2014), and instructors who wish to use more active methods might consider including instruction which explicitly develops learners' growth mindset.

More research on instructional methods that can impact conceptual change in the online setting is needed. For example, studies could explore GIs that are structured so as to more clearly confront participants' beliefs as compared to science, so that they must consciously and deliberately restructure their understandings (Vosniadou, 2007). In addition, research comparing instructional methods in actual online class settings, and perhaps also including sociocultural interactions (Alexander et al., 2018; Vosniadou, 2007), may help us further understand the most impactful methods for assisting our students with correcting their misconceptions.

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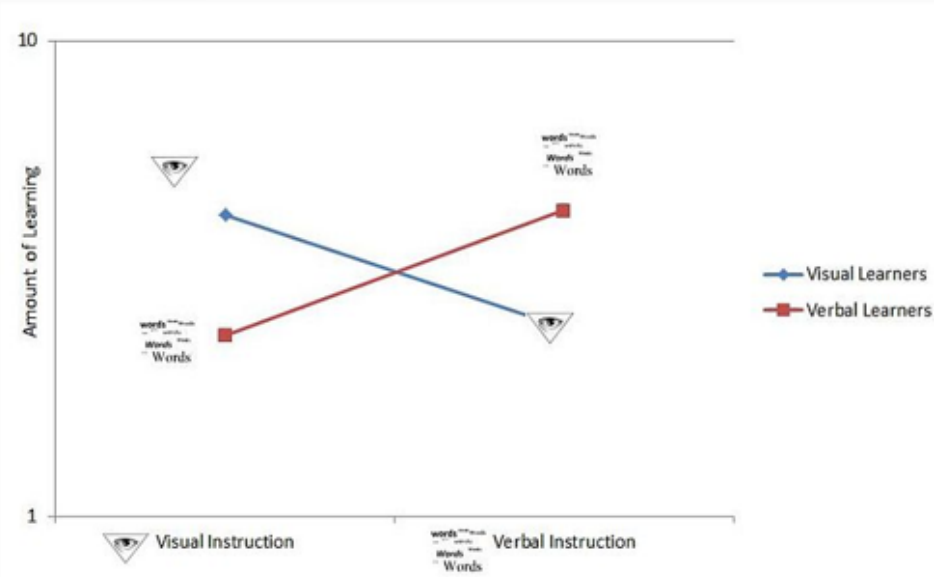
Appendix

Sample of Learning Styles Guided Inquiry



Predictions of Learning Styles Theory

According to Model 1 above, which type of learner should do better when given visual instruction?

Please remember to use full sentences.

According to Model 1 above, which type of learner should do better when given verbal instruction?

According to Model 1 above, what should happen when a type of learner is given instruction that does NOT match their learning style?

Note: Inquiry proceeds to present learners with a graph of actual results that contradict these predictions, accompanied by questions, as well as other information about learning styles theory.