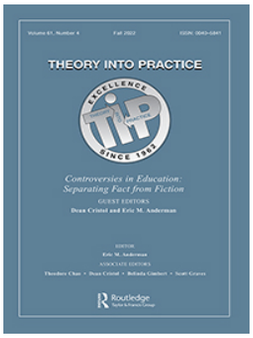

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The learning styles hypothesis is false, but there are patterns of student characteristics that are useful

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ABSTRACT

The learning styles hypothesis—and particularly the meshing hypothesis—state that learners' preferences about their preferred modality of learning (i.e., visual, aural, or kinesthetic) predict learning gains on academic tasks. Despite the fact that this hypothesis is not borne out by the scientific evidence available to us, it still remains in widespread classroom use. This article begins by discussing the evidence against learning styles. Second, the article discusses why teachers might continue to believe in and use learning styles in their classroom as well as why essentialist beliefs about learning are not helpful. Finally, 3 variables that do impact student learning—knowledge, strategies, and interest are discussed. Each is defined, their development and measurements are discussed, and finally some instructional examples are given. Replacing the use of learning styles in the classroom with instructional decisions based on the development of knowledge, strategies, and interest can improve student learning outcomes across a wide range of subjects and grade levels.

Interest in and proliferation of the Learning Styles Hypothesis (LSH) have continued unabated for the last few decades. The purpose of this article is threefold. First, we review the evidence that the LSH is conclusively false, and then briefly discuss other related types of styles. Second, we briefly discuss why it may be such a seductive idea to practice teachers and the way in which individuals believe learning styles works. Third, we suggest practical ways that are supported by evidence for teachers to provide meaningful instruction to their students that increases their learning, task performance, or academic achievement. To this end, we offer 3 individual difference variables, which are supported by substantial evidence in the research literature.

The learning styles hypothesis is false

Before reviewing the evidence that the LSH is false, we want to define it. This is necessary because several frameworks use the term *learning styles*. Specifically, the meshing hypothesis in the learning styles family states that individuals can be identified as either visual, aural, or kinesthetic learners, and further, that instructional materials with those media—e.g., visual presentation for visual learners—will increase their learning outcomes when matched

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(Pashler et al., 2008). For example, if a student is identified as a *visual learner*, that student should be presented with visual stimuli. To learn about fractions, that student would be presented with visual images that may depict parts of a whole (e.g., a pie chart). However, if the student is identified as a *kinesthetic learner*, that student should be presented with manipulatives that they can use to make fractions such as splitting a pie or pizza into fractions of the whole pie. A student identified as an *aural learner* should receive input by sound, such as verbal instruction. Other such matches have been suggested, like student preferences for words versus pictures.

Unfortunately, while these styles seem intuitive, they are merely categories of self-reported preferences, not related to learners' demonstrated performance, their developmental processes, or the context of learning (An & Carr, 2017). Numerous attempts to provide evidence matching a modality (i.e., visual, aural, or kinesthetic) to the learner's improved learning outcomes have yielded insubstantial support for this hypothesis. Of the well-designed attempts—with adequate research designs, instrumentation, and analyses—none of these studies as reviewed by Pashler and colleagues (see, Pashler et al., 2008 for a detailed analysis) indicated meaningful or significant effects of such a match between a student's preference of modality and more positive learning outcomes, and indeed, some indicated that students fared worse when this meshing took place.

In their review, Pashler and colleagues decried the quality of some of the studies that investigated the meshing hypothesis. They went further to suggest criteria for studies that would lead to valid inferences about whether the meshing hypothesis is supported (or not). Taking up that call, Rogowski and colleagues specifically designed a study about the effects of matching learning style to see the effects on comprehension that aligned with the 3 steps that Pashler et al. suggested, namely: Participants were divided into groups based on their learning style; participants from each group were assigned to receive one of the multiple instructional methods; and, participants completed an assessment of the material that was the same for all students (Rogowsky et al., 2015). Similar to previous attempts, their data failed to support the meshing hypothesis.

It might be a surprise that there is no evidence to support LSH and that this instructional approach could actually promote negative outcomes—meaning that students learned *worse* when this type of meshing was employed (Kirschner & Van Mërrienboer, 2013); however, longstanding theoretical and empirical evidence can explain these negative findings. In the information-processing literature, the *dual coding hypothesis* is one such explanation. The dual coding hypothesis states that presenting complementary visual and auditory information together will indeed produce the desired learning gains (Mayer & Anderson, 1991). For example, when learning about fractions, the dual coding hypothesis would support having the student both see *and* hear information about fractions, if that information was complementary. While there have also been some mixed findings and criticisms of the dual coding hypothesis, overall, there is empirical and theoretical support for it (see, Clark & Paivio, 1991 for more detail) that preceded broad, popular interest in learning styles in education.

Additionally, the more contemporary multimedia learning theory can explain why the LSH does not improve student learning. Multimedia learning theory states that reducing extraneous processing and managing essential processing strategies (Mayer, 2017) can improve learning outcomes as well as transfer of learning (i.e., using information from one setting in another related setting). Again, the key to multimedia learning theory is that the information

presented must be complementary and not detract from one another. At its heart, this theory suggests that learning is less about this medium or that medium and more about how information is presented to students. This perspective necessitates a shift in how teachers organize instruction, rather than how it is transmitted. In other words, it is the congruence of information presented that is central to multimedia learning theory. For example, in a series of studies, Mayer and colleagues (e.g., Mayer, 2017) demonstrated that narrated PowerPoints in which syncing the auditory and visual information about lightning was much more meaningful for both immediate learning outcomes and future learning (i.e., transfer of learning) than when just auditory or just visual information was given. Importantly, the worst outcomes occurred when the auditory and visual information were out of sync.

We also want to briefly address other versions of *styles* beyond the meshing hypothesis that has emerged. The term *cognitive styles* emerged partially as a response to notions of fixed intelligence, which had dominated the psychological literature for some time (Sternberg, 1988). These cognitive styles were part of his efforts to shift from notions of fixed intelligence to what was termed *adaptive intelligence* where intelligence was not a measure of what your innate abilities were, but rather what one's ability to change in response to the environment was. The cognitive styles within this theory were later renamed *thinking styles* and include 4 forms of mental self-government: hierarchical (can do multiple tasks but assigns priority to some tasks over others), monarchic (complete focus on one thing at a time), oligarchic (like to do multiple tasks but does not set priorities), and anarchic (someone who is asystematic). Importantly, in their view, these styles do not describe abilities, rather they refer to "how one prefers to use one's abilities," (Zhang, 2002, p. 179). While there has been theoretical work here to understand their relation to cognitive development and a few studies showing gains in academic performance in higher education, there has not as yet been compelling evidence that these preferences predict academic performance in meaningful ways across multiple contexts.

There has also been a learning styles strand of research that emerged primarily from European universities. Vermunt and colleagues (e.g., Vermunt, 1998) identified 4 learning styles: meaning-directed (a critical and self-regulating learner), reproduction-directed (one who memorizes and rehearses), application-directed (knowledge user), and undirected (lacks regulation toward learning). These learning styles were renamed *patterns* in subsequent iterations. Unlike the LSH where learning styles are assumed stable—a point we revisit in the next section—and thinking styles which were conceptualized as preferences toward thinking and patterns of adaptive learning were theorized to change depending on conditions in the environment. For example, when directions were given to read a text to take a test someone might use a reproduction-directed approach, whereas if directions were given to read a text and discuss as part of a book club someone might take an application or meaning-directed approach. While these patterns of student learning have been the focus of many studies, there have been mixed findings about how these patterns relate to student learning and particularly how students develop these patterns over their higher education coursework (Asikainen & Gijbels, 2017).

Why is the LSH so seductive to practicing teachers?

Given the lack of empirical evidence for learning styles, we need to briefly examine why the LSH is appealing to teachers before suggesting alternatives to the LSH and the meshing hypothesis in particular. We suggest 3 such reasons—simplicity, marketability, and beliefs about students.

One draw of the LSH and the meshing hypothesis in particular is how simple it is. LSH suggests that we can give students a survey or test to identify their learning style, put them into groups based on the assessed style, then provide them with the appropriate modality based on that grouping. If true, practicing teachers can clearly distinguish between the 3 types of learners and provide the appropriate instruction in perpetuity.

Second, this simplicity leads to an increased marketability of products aimed toward the LSH. Each concept that needed to be taught (e.g., fractions) would require 3 sets of instructional materials—visual, auditory, and kinesthetic for the meshing hypothesis—that can be marketed to teachers. This industry and the perniciousness of this marketing strategy, based on no evidence that it works, are well described in Pashler and colleagues' 2008 piece, which we highly recommend.

Third, we turn back to an earlier discussion about how styles may be perceived as stable aspects of the learner. Nancekivell et al. (2020) undertook an illuminating study that described why individuals might subscribe to the LSH, regardless of the lack of empirical evidence for it. In their study, they identified an *essentializer group* (i.e., those that believed learning styles were biological in nature and unchanging) and a *nonessentializer group* (those that did not believe learning styles were biological in nature and were tendencies rather than fully determined). Approximately two-thirds of their samples were essentializers and one-third were nonessentializers. However, both of these groups generally agreed that "learning styles were uninfluenced by experience," (p. 225). Additionally, they reported that the only significant predictor of beliefs about learning styles—whether it was an essentialist or nonessentialist belief—was the age of the student that they taught. For teachers, the younger the student they taught meant they were more likely to hold these essentialist beliefs.

While the degree to which teachers believe in learning styles despite the evidence for learning styles being a myth are quite strong, we do appreciate that teachers want to be attuned to the individual differences of their students. As we are educators ourselves from a variety of backgrounds pre-K to adult, we acknowledge that oftentimes it is difficult to obtain high-quality instructional resources and at the same time understanding student data with regard to individual differences is complex and dynamic in the classroom. Coupled with the high demand of the teaching profession, it is quite easy to find resources for teaching to learning styles in both district-provided professional development and the internet. Further, while there have been many calls for teachers to stop using the LSH to guide their instruction, there have been few, if any, attempts to suggest alternative ways in which teachers can be attuned to these individual differences in approachable ways (for a counterexample, see, An & Carr, 2017). Thus, in the next section, we offer 3 individual difference variables to assist teachers in their journey to being responsive to their students demonstrated to improve learning outcomes and backed by scientific evidence.

Three variables for attending to students' individual differences that impact learning

Unlike the essentialist view that underpins most teachers beliefs about learning styles, we describe Alexander's Model of Domain Learning (MDL; Alexander, 1997) as a framework for thinking about the development of those essential characteristics. The MDL predicts changes in students' individual differences that enable them to become more capable in an

academic domain, such as mathematics, science, reading, history, or writing. The MDL has 3 stages, which are acclimation (i.e., novices), competence, and proficiency (i.e., expertise). While these stages are not age specific, typically individuals would not reach competence until at least adolescence if not later and only in rare cases would reach proficiency before adulthood.

Unlike older theories of intelligence such as Spearman's *g* or essentialist views of learning styles, the MDL predicts constant change in 3 variables, namely students' domain knowledge, strategies, and interest. For each of these variables we briefly discuss what they are, how they develop, the evidence bases for them, and how teachers can track these variables in their students.

Attending to prior knowledge

The first of these 3 variables is knowledge, specifically domain and topic knowledge. Domain knowledge is defined as the breadth and scope of subject-matter knowledge (Alexander et al., 1997). For instance, a piece of domain knowledge about physics would be that matter is neither created or destroyed. Topic knowledge is defined as the depth someone has about a particular topic within a domain (Alexander et al., 1997). A piece of topic knowledge about climate science would be that water vapor is the most potent greenhouse gas.

The MDL describes the development of both domain and topic knowledge as increasing throughout all 3 stages (i.e., acclimation, competence, and proficiency). The expectation is that students building expertise should gradually increase their levels of both domain and topic knowledge in order to build toward expertise in a domain. Further, as individuals move through competence and especially into proficiency, they begin to develop both broader knowledge about the domain (i.e., domain knowledge) and a greater depth of knowledge about topics within that domain (i.e., topic knowledge). Additionally, their stores of domain and topic knowledge become more organized the more expert they become.

Unlike learning styles, the evidence base for knowledge as a predictor or explanatory factor in student learning and performance is quite strong. There are relatively few variables that predict or explain changes in learning or academic achievement to the extent that prior knowledge or prior achievement do. While prior knowledge and achievement are not synonymous, measures of student achievement are indeed knowledge-based. This would include classroom assessments such as multiple-choice tests to large-scale international tests such as the Programme for International Student Assessment (Organization for Economic Co-operation and Development, 2022). Hattie's (2009) indicated that prior achievement had a Cohen's *d* (a measure of the effect of one variable on another) of .67. This effect is considered quite large in social science research. Additionally, there is credible evidence in a recent review that the trends in knowledge described in the MDL hold up well across the developmental spectrum from early childhood to postsecondary education (Murphy et al., 2018).

Attending to prior knowledge rather than a preferred learning modality is probably the most straightforward of the 3 variables. This should be a variable discussed in teacher education programs and good teachers we have observed in the classroom are always attending to students' prior knowledge and how it unfolds. However, with the increasing

number of teachers entering the classroom without proper training (Garcia and Weiss, 2019) we believe it is important to reiterate its importance. Valid and reliable measures of knowledge are essential to our ability to track this variable in our students. One issue is that measures of prior knowledge must be suited to the domain and topic under consideration, so often teachers need to develop specific tests of knowledge for their students that are contextual in nature. However, these teacher-made tests—as well as researcher-made tests—of prior knowledge often have poor reliability (Tobias, 1994). Standardized tests tend to have better reliability and validity evidence than teacher-made tests but are not always relevant to individual teacher and student learning contexts. While these issues are real and need to be addressed, the complexity of creating valid and reliable tests of knowledge will help student learning performance far more than tests of learning styles.

Differentiating instruction based on students' prior knowledge may take a variety of forms. For instance, in a course, providing readings to students with little prior knowledge in the domain or topic may be of little use as students rely heavily on prior knowledge while reading (Fox, 2009). Instead of the typical order of being introduced to a topic first by reading about it and then attending class to discuss the topic, it may be more efficient—and less frustrating—for those with lower-levels of prior knowledge to be introduced in a manner that requires less prior knowledge, such as guided discussion on the topic. On the other hand, high knowledge learners can be granted more independence and might progress through topics in a more unguided manner, such as a series of independent readings on a topic.

Attending to students' strategy use

Strategies are specialized forms of procedural knowledge (i.e., how to do something) that are intentional and conscious and help an individual accomplish tasks or solve problems (Alexander & Judy, 1988). There have been a number of different types of strategies proposed (Dumas, 2020) and we will discuss two here—domain-general versus domain-specific and surface-level versus deep-level strategies.

Domain-general strategies refer to strategies that can be useful in any domain, while domain-specific strategies are those that may be only useful in specific domains (Dumas, 2020). For example, creating concept maps to help study a topic could be used in science or history, whereas using a control-of-variables strategy (i.e., changing one variable to see the effect on another variable) is useful primarily in science but not in other domains. The other type discussed is levels of strategy use. Surface-level strategies are those strategies that help us understand a problem or reproduce a task, whereas deep-level strategies are those strategies that help us transform a problem or task in some way (Dinsmore et al., 2018). For example, in reading an example surface-level strategy is rereading, while an example deep-level strategy is making an inference about the text (i.e., using what is the text and one's prior knowledge to gain a new insight about what is being said in the text; Pressley & Afflerbach, 2012).

The development of strategies in the MDL is slightly more complex than that of domain and topic knowledge. While deep-processing strategies increase as one moves toward expertise, surface-level strategies actually decrease. Additionally, as individuals engage in more expert-like tasks, they rely on domain-specific strategies, rather than domain general strategies. As a result, a novice in acclimation relies more heavily on domain-general and

surface-level strategies, while an expert in proficiency relies more heavily on domain-specific and deep-level strategies. The comparison to essentialist learning styles is the same between strategies and learning styles as it was between knowledge and learning styles. Strategies are not fixed or biological, rather they are dynamic and change based on the situation—such as an individual's expertise level and what types of task they are engaging in (e.g., simple tasks or tasks that require specific and deep strategies to complete).

Like prior knowledge, strategies have been intensely investigated over the past few decades. Here, the picture of the effectiveness of strategies on student learning is complex, too. In a recent review, Dinsmore (2017) reported that for those measures of strategies and strategic processing that only examined how frequently (i.e., often) a strategy was used, the findings in the research literature were mixed with some positive finding effects, some no effects, and some negative effects (i.e., learning was worse when more strategies were used). However, for studies that examined the quality of strategy use (i.e., how well it was employed) and when those strategies were used, a large majority of studies showed gains in learning performance with only 17% of the studies reviewed being nonsignificant. Looking at strategy research in the MDL there is also good evidence from a recent meta-analysis to suggest that effective strategy use leads to better learning outcomes (r = .13; Dinsmore et al., 2018).

Unlike prior knowledge and learning styles, however, measuring strategies and strategy use have not been systematic in schools. There has been more emphasis on asking students about their strategies on some large-scale assessments like the National Assessment of Educational Progress in the United States (National Center for Educational Statistics, 2022), but the research literature has demonstrated that findings from retrospective surveys (i.e., asking students what they did during a task *after* they completed the task) are problematic (Veenman et al., 2006). Fortunately, another approach that has been taken in the research literature, think-aloud protocols, are also commonly used in classrooms. Think-aloud protocols are when individuals are asked to say out loud anything they are thinking and doing, *while* they are completing a task (i.e., concurrent). For instance, Deekens et al. (2018) used thinking aloud to examine the connection between university students' strategies in science and history. Think alouds, sometimes referred to in classrooms as talk alouds, are particularly common in reading and writing classrooms at younger grade levels (e.g., Farr & Conner, 2005).

Thus, expanding the use of think alouds to other subject areas and older grade levels would provide teachers with a lot of data in which to understand why some students succeed and others struggle. Understanding what students are doing during a task could lead to better instructional moves. For instance, a student using no strategies during a task could be taught new strategies. If the think aloud revealed that a student was using a strategy poorly, the teacher could review how to use the strategy. Finally, if a student was using an ineffective strategy, they could be instructed when and where certain strategies are more or less useful.

Attending to students' interest

Our final recommendation for a variable other than learning style is the motivational variable of student interest. Interest refers to the relationship between a person and object (Schiefele, 1991). Unlike motivation where we might say that someone is motivated, interest

always has to have a target (i.e., object) for someone to be interested about. Like strategies, there are also different forms of interest. Situational interest refers to short-term affect (i.e., feelings) about an object, while individual interest refers to long-term engagement a person has with an object (Hidi & Renninger, 2006). For example, a child engaging in a 3D simulation of the Milky Way galaxy for the first time and finding this experience fun would be an example of situational interest. A graduate student engaged in years of research on radiation in space would be an example of individual interest.

Like strategies, interest does not simply increase; rather, some forms of interest increase will others decrease (Alexander, 1997; Hidi & Renninger, 2006). More novice learners rely more heavily on situated interest to spark their engagement in a domain. To become more expert, however, individuals cannot simply rely on situational interest to sustain them. They need to increase their levels of individual interest and decrease their reliance on situational interest.

The effects of interest on student learning and performance are a bit different than those for knowledge and strategies. Theoretically, interest does not directly help a learner perform a task or solve a problem. However, situational and individual interest—along with other motivational variables such as self-efficacy—lets students activate their stores of knowledge and strategies to in turn solve problems or complete tasks (Schiefele et al., 1992). For instance, a study by Rotgans and Schmidt (2011) nicely demonstrates how situational interest can increase classroom behaviors, such as strategies, that in turn increased academic achievement in a vocational education classroom.

There are 2 primary ways teachers can assess interest in the classroom. The first is through observation of student behavior. Engagement, either long or short term, may be evidence of student interest in an activity, task, or problem. Shorter-term engagement may be indicative of situational interest, while longer-term engagement may be indicative of individual interest. Of course, the more direct route here is to ask students about their interest and their levels of interest in a topic or task. This could be done through a survey, exit ticket, or simply a conversation with a student.

Knowing students' levels of situational and individual interest can provide meaningful instructional opportunities. Knowing what a student is interested in can provide unique opportunities to tailor opportunities for that student. For instance, if a student shows particular interest in governmental structure, a teacher could recommend a program like Model UN for them to further develop their interest in a topic. For a student that has low interest in a topic or domain the teacher can either provide instruction that sparks situational interest or build utility value (i.e., the usefulness of a task or activity; Eccles & Wigfield, 2002). For instance, if a student says they are not interested in fractions, the teacher could make a case to the student that understanding fractions could help that student bake cookies, assuming they were also interested in cookies. Then, importantly, the teacher would need to nurture the development of this interest by continuing to tie the topic of fractions as the students' interests change.

Concluding thoughts

In this article, we have made the case that learning styles—specifically the meshing hypothesis—is not a fruitful avenue to pursue in order to improve student learning outcomes. While students' preferences are easy to measure and there are numerous products on the market catering to the

LSH, there are far more evidenced-based individual differences on which teachers can base their instructional decisions. We outlined 3 variables—knowledge, strategies, and interest—that are backed by significant research evidence and can be measured in the classroom. In turn, these data about students can be used to make instructional decisions that increase students' academic achievement. These three variables together can be used to track the development of students' continued growth in academic domains and help teachers understand and cater to each student's specific trajectory. This is in contrast to the LSH that is typically assumed to be unchanging and has no evidence that supports that measuring or designing instruction with it improves children's, adolescents', and adults' learning outcomes. Finally, we offer further readings in addition to the pieces cited in the text for those who wish to learn more about these 3 variables. All 3 readings are short books written for practitioners about the 3 variables described in this article—knowledge, strategies, and motivation.

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Additional Resources

1. **Greene, B. A. (2017). *Self-efficacy and future goals in education*. Routledge.**
   Greene's relatively short text on motivation is specifically designed to help teachers and practitioners understand how motivation—in particular self-efficacy goals, and interest—play a role in their academic development. She provides specific instructional strategies to help both pre- and in-service teachers devise strategies to improve their students' motivation at school.

2. **Dinsmore, D. L. (2017). *Strategic processing in education*. Routledge.**
   Dinsmore's text, like Greene's, is relatively concise and offers snapshots into how student cognitive processing and strategies operate across a wide variety of academic domains (e.g., mathematics, science) and developmental levels. He offers 2 chapters on how teachers can measure and nurture strategies and ends with instructional principles to improve students' academic achievement by focusing on strategies and cognitive processing.

3. **McCrudden, M. T., & McNamara, D. S. (2018). *Cognition in education*. Routledge.**
   McCrudden and McNamara discuss the differences between the perceptions of teachers believing students are born to be better learners (or not) and those that believe how students think can change over time and are better predictors of student learning. Their book is written especially for pre- and in-service teachers to recommend instructional strategies to support student learning.