Confusion, Error & Feedback: A Successful Learning Triumvirate

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The terms 'confusion' and 'error' have historically been four-letter words in the educational sphere; and understandably so. In an environment of relative grading schemes and high-stakes testing, the prospect of making a mistake or failing is necessarily frightening. Add to this a prevalent social stigma and a dearth of adult-modelling (how many teachers want their students to see them muck-up or in a state of bewilderment?), and student aversion to confusion and error-making makes coherent sense.

Interestingly, it has been well established in the Science of Learning literature that not only can confusion and error be leveraged to enhance learning, but also, in certain circumstances, these two occurrences may be integral to the learning process. As such, it might be high-time to welcome these commonly avoided concepts into the educational fold and determine how best to convert each into an effective tool that can be utilised to boost learning in our schools. It's only through the formation of a culture that embraces confusion and error that the inherent stigma on these topics can be confronted and overcome.

Confusion

When it comes to teaching concepts or facts, a common belief is that clearer is better. Especially when the material being explored is completely new to students, it seems logical that the more precise, simple, and easy-to-follow a lesson is, the better chance students have to engage with and comprehend it.

However, common sense is not always an accurate gauge of how things truly are! In a series of recent studies, a group of students were presented with a series of video lessons—typically involving scientific or mathematical concepts. In these lessons, a confident instructor presented the content in a very coherent, straight-forward, and simple manner. The students who viewed these videos typically described them as succinct, direct, and comprehensible. Furthermore, they reported that they believed they strongly understood the content and predicted they would perform well on future exams.

In these same studies, a different group of students were presented with the same material, though taught in a different format. In these lessons, an instructor was shown working closely with a confused learner. Through a back-and-forth of dialogue, trial-and-error, and leading prompts, the learner in this video would eventually understand the concept being explored. The students who viewed these videos typically described them as unclear and confusing. Furthermore, they reported that they only moderately understood the content and predicted they would perform relatively poorly on future exams.

How do you think each of these two groups actually performed on the future exams? As you probably guessed, the second, confused group demonstrated stronger learning and retention than the first, clear group.

Although the reasons for these findings are varied, and debate about specific mechanisms continues in the academic literature, there is a recurrent concept worth considering: the interplay between attention and prior knowledge. An important facet in learning and teaching concerns the linking of new material to prior knowledge – however, a common finding in learning and memory research suggests that the harder an individual has to work in order to link new ideas to old, the deeper said links will become (levels-of-processing theory). With regards to the above studies, it has been argued that clarity and simplicity may lead students to decrease the amount and strength of attention paid to a learning activity thereby decreasing their chance of recognising differences between novel ideas and prior assumptions (shallow processing).

On the other hand, confusion and uncertainty may lead students to increase the amount and strength of attention paid to a learning activity thereby increasing their chance of recognising differences between novel ideas and prior assumptions (deep processing).

This concept raises an important point: confusion does not appear to cause learning. Rather, confusion appears to prime the learner—to put them in a state of enhanced attention and receptivity which, in turn, allows them to better engage with the learning process. As such, confusion should only ever be understood as a means rather than an end. Just as fertiliser does not obviate the need to plant, sun, and water your garden (it merely enhances the impact of said practices), confusion does not eliminate the need to enact effective learning and teaching strategies (it merely enhances the impact of said practices).

Finally, it is very important to remember that confusion is a double-edged sword: whereas a little may be beneficial to the learning process, an excess may lead to disengagement and ultimately derail the learning process (a bit like wine). Therefore, one must carefully consider when, how, and how much confusion to inject into the learning process. It is possible that the more an individual learns to live with and even seek-out confusion, the more confusion he or she is likely to be able to meaningfully endure (again, a bit like wine). It is here where building a culture that accepts confusion as a worthwhile state of learning becomes all important.

Errors

A close relative to confusion is error-making. As can be assumed, the more confused an individual is, the more likely he or she is to make mistakes. This leads to an interesting question: if it is possible to derive benefit from confusion, is it also possible to derive benefit from the error? Decades of research into this question suggests the answer is an emphatic yes.

At the most basic level, the ability to learn from mistakes is a foundation of human, animal, and machine learning (error-based learning). Under this theory, it is believed each individual has a 'mental model' of the world which leads them to continuously predict what physical and environmental responses will be elicited from specific cognitions and behaviours. So long as there is no glaring discrepancy between one's mental model and the world, there is little attention

paid to or updating of said model. It is only through errors and the making of mistakes that an individual's attention becomes focus, he or she is alerted to a discrepancy between assumption and reality, and the mental model can be meaningfully updated (in other words—learning!).

This concept leads to an interesting idea: if an individual is first asked to demonstrate their current understanding (mental model) before learning novel material, can the ability to detect discrepancies be enhanced? In fact, most research exploring this idea supports this assumption. Several studies have demonstrated that when individuals are first asked to commit common errors or elucidate common mistaken assumptions (e.g., when dropped from the same height, a heavier ball will fall faster than a smaller ball) prior to being confronted with a conflicting reality (e.g., both balls fall at the same rate), they demonstrate enhanced attention, memorisation and retention of the new material. In essence, committing the mistake allows for an easier learning process.

Beyond this basic level, the ability to recognise, embrace, and use errors as a learning guide appears to be a hallmark of high-performance and self-motivation. More specifically, a series of experiments has demonstrated that, during specific lessons, poor-performers often demonstrate little-to-no aberrant neural activity during the learning process, but enhanced activity within the reward network of the brain upon successful lesson completion. This suggests that a focus on the end or goal of a specific lesson can impair learning (outcome orientation). Conversely, during these same lessons, high-performers often demonstrate enhanced activity in attention and memory networks following mistakes made during learning, but little-to-no aberrant neural activity upon successful lesson completion. This suggests that a focus on errors or performance-cures can improve learning (process orientation).

Additionally, several researchers have spent decades exploring what differentiates experts from novices within a plethora of cognitive and physical disciplines. A primary finding: experts commonly engage in what's called 'deliberate practice'—this is a process by which individuals transcend their unique learning plateaus and develop mastery over a subject or skill. Of importance, a key aspect of deliberate practice is the committing of errors. In essence, nearly every individual who has obtained mastery within a given field has done so through the continuous committing of mistakes; the difference between

them and novices is that they have learned to recognise when a mistake has been made, to adjust performance/mental models accordingly, and to seek out future mistakes for further learning.

As with confusion, it is possible that mistakes can be a double-edged sword. Again, until one is able to accept the process of mistake-making and performance adjustment, it is possible he or she will avoid any potential scenario that could lead to error-making. It is for this reason that we must begin to explore and consider how we (as parents, teachers, and leaders) can begin to model how best to embrace, seek-out, and learn from failure. An uncomfortable reality of this process will necessarily be that we must appear fallible in front of our students. However, if they come to accept failure in us, then it's very possible they will come to embrace it in themselves.

Feedback

As noted above, it is only through the process of error-making that individuals are meaningfully alerted to their mistaken mental models and can meaningfully begin to adjust said models (learn!). However, a key aspect of this process is explicit knowledge of what the new model can or should look like. In other words, it's one thing to know that you've made a mistake—it's a totally different thing to know how to fix it!

It is here that feedback becomes all important. Feedback represents the strongest and most efficient avenue we have to help students understand how best to address their mistakes in order to gain mastery over a set of skills or cognitions. However, what type of feedback is most effective for this process?

After over a decade of researching this question, a number of researchers have developed a model that best elucidates the aspects of feedback that can assist an individual to learn from and move beyond their mistakes. This model is based on three questions: Where am I going? How am I going? and Where to next? Furthermore, this model extrapolates four different levels within which feedback can be delivered: task, process, self-regulation, and self. By knowing where an individual is located in the learning cycle (novice to accomplished) and the types of mistakes committed, we can meaningfully tailor feedback to help students address their errors and determine how best to adjust their concepts and assumptions.

In addition, research has demonstrated that giving feedback is important, but receiving feedback is even more so. In other words, unless an individual is aware of his or her errors and understands the type of mistakes that have been made, then feedback falls on deaf ears. For this reason, it is important to consider how students are actioning the research being given. Within their reception of the feedback lie all the clues needed to determine what aspects of their learning process they have recognised, and which they have not.

So Now Then…

It's clear that confusion, error-making, and feedback form a relationship that can not only be utilised to enhance learning, but that also might be integral to developing expertise or mastery. Though, as noted in the introduction to this piece, not everyone appears ready to accept this somewhat uncomfortable fact. This leaves us with arguably the most important question education will have to face over the next couple years: how do we develop a climate of trust that encourages all individuals —students, teachers, and leaders alike—to seek-out, utilise, and maximize the power of the confusion/error/feedback triumvirate?

It is clear every child can obtain a year's growth from a year's input—but this can be improved when they learn to enjoy the struggle and hard-work that is learning. Too often, we all believe that the good learners are the bright students; those destined to succeed. But all evidence suggests that success isn't a trait, rather, it is a process. For a long time, that process has been hidden, but new research is bringing it to light, and the findings strongly suggest that embracing confusion and error are key elements. How can we change the climate of class to ensure all students recognise that enjoyment of the learning process (rather than the learning outcome) can lead to remarkable success?

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