

TESOL: 英会話教育における誤りの利用と訂正法

TESOL: Using and Correcting Errors in Teaching English Conversation

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Abstract: *Teaching is a complex, multifaceted process with many interconnected parts, and an often-maligned feature of the learning component is errors. Brain scientists have come to understand that making mistakes is a necessary and beneficial part of learning. This paper will first present the rationale for encouraging and including errors in language lessons to enhance learning. From there, strategies to acclimate students to be comfortable with making errors in the language classroom will be described. Finally, error-compatible correction techniques when teaching English conversation as a second or foreign language will be presented.*

1. Errors Are Essential for Learning

New tools mapping the workings of the human brain continue to be developed providing psychologists and brain scientists with deeper insight into how we think, learn, and relate to the world around us. Neurology experiments using MRIs and brain-wave detection devices show which part of the brain is being activated and how strongly it is being stimulated. One area where this has had a particularly significant impact is in understanding how we learn. Cognitive psychologists have established that errors are essential for learning based on contemporary research using modern tools. Yet many schools have been slow to embrace this concept to improve the quality of their educational programs. Teachers often believe that errors should be systematically avoided and admonish students when they make mistakes. Numerous studies show this to be an ineffective approach that hampers learning by conditioning students to become risk-averse to making mistakes.

Mistakes are necessary for learning because each mistake is an opportunity to learn due to the stimulating effect it has on the brain.¹ Errors in usage are normal when learning to communicate in a foreign language and are beneficial on two fronts: they show that learning is taking place as students attempt to use what they have learned in new ways (as opposed to repeating stock phrases) and reveal which areas or parts of speech need to be studied and reinforced. Errors are an integral part of the learning process and using a nonjudgmental and minimally invasive strategy when correcting errors promotes better understanding and retention.

In his book, *How We Learn*, Stanislas Dehaene identifies errors as a key factor contributing to efficient learning in the developing brain of children and explains that this continues to be a foundational part of the learning process as the individual matures. He states, “To update their mental models, our brain areas must exchange error messages. Error is therefore the very condition of learning. Let us not

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punish errors, but correct them quickly, by giving children detailed but stress-free feedback” (242). Stress-free feedback is a staple of good teaching, however in a foreign language conversation class, it is not always best to quickly give *detailed* feedback. Teacher discretion is required to ensure detailed explanations are used at an appropriate time. Too many intensive corrections too soon can hamper learning – yet correction is necessary to develop and improve fluency. Choosing an optimal time and method for correction, factoring in the competencies of the class, will maximize learning (see When to Correct).

2. Managing Mistakes and Errors

First, it is important to differentiate between a mistake and an error since this distinction determines which methods are best applied to correct students. Mistakes occur when students are preoccupied with expressing new ideas or concentrating on the content of the message making it easy for slip-ups in grammar, syntax, or usage to creep in even when students know the correct forms. When a mistake is made, students are usually able to self-correct because it is related to something they already know and are familiar with. An error, on the other hand, is something students say in a wrong way because they have not yet learned or studied a particular part of the target language and are therefore unable to notice a problem. In this paper, either term may be used to cover both meanings generally and in most cases are interchangeable. However, when the type is consequential (mistake vs. error) the designated terms will be applied, and the distinction referenced for clarity.

Mistakes and errors often require different methods of correction, but the purpose is the same: to support learning to prevent the same mistakes from being made over and over so the language learner can improve and speak with more confidence. In answer to the question “What are the best ways to deal with error correction in the second language classroom?” posed by the award-winning teacher Larry Ferlazzo on his teacher advice blog, Tracey Tokuhama-Espinosa, author of *Making Classrooms Better: 50 Practical Applications of Mind, Brain, and Education Science*, states, “As a teacher, I often tell my students that I don’t care how many mistakes they make, so long as they are always new ones” (Response From Tracey Tokuhama-Espinosa par. 2). Teachers will need to consider the level, as well as the stated objectives of the class, to determine whether the misuse of the same word or phrase used in a variety of new sentence structures actually constitutes a “new” mistake that should be explained immediately (in detail) or is one that should be dealt with in a future lesson devoted to that purpose.

Regardless of whether the remediation is carried out later in a lesson or saved for a future lesson, an error should always be corrected when it occurs, even if it is simply noted by the teacher, so the wrong form does not become fixed in students’ minds. Adam Waxler, a renowned teacher leader, says: “Many teachers are against correcting wrong answers for fear that they will hurt the students or lower self-esteem. This is wrong.” He goes on to explain that “it is very important that you correct wrong answers. You do not want students to reinforce incorrect learning,” (107). Additionally, the methods of correction and the approaches used

when addressing students are key to successfully dealing with errors in the classroom.

3. Provide Quality Feedback

Quality feedback is integral to optimize learning. Dehaene references meta-analyses done by John Hattie who has identified and measured the impact of over 250 factors on educational performance stating, “[these studies] clearly show that the quality of feedback that students receive is one of the determinants of their academic success” (210).

Investigative journalist Tom Vanderbilt, in his book *Beginners: The Joy and Transformative Power of Lifelong Learning* that documents the joys and struggles of learning new skills also emphasizes the need for practical feedback saying, “because positive feedback boosts learners’ confidence and motivation, this might be more helpful than repeatedly pointing out what they did wrong, which might just make them more anxious and self-conscious” (193). Dehaene concurs saying that “Errors always recede as long as we receive feedback that tells us how to improve. This is why error feedback is the third pillar of learning, and is one of the most influential educational parameters: the quality and accuracy of the feedback received determines how quickly we learn” (201). According to Dehaene the other two pillars are “attention” and “active engagement,”² and although these are not directly addressed in this paper, they are an inherent part of the feedback and correction methods presented here.

4. Challenge the Learner

Students learn better and retain more when they are challenged. Dehaene quotes the eminent cognitive psychologist, Henry Roediger, who found

through his research that “Making learning conditions more difficult, thus requiring students to engage more cognitive effort, often leads to enhanced retention” (242). An easy gauge to assess the difficulty of a lesson is to note the number of errors made. If there are no errors, the lesson is not challenging enough, and if there are too many errors, the lesson is too difficult. Many teachers tend to view a lesson where no errors are made by the students as highly successful. However, since errors are necessary for learning, these “easy” lessons devoid of errors are counterproductive to the learning process. Vanderbilt found this to be the case when reflecting on the criteria that sustain steady progress in learning new skills saying that “Such ‘errorless learning’ may make the learner feel better, but it eliminates the huge part of learning that comes from mistakes” (18).

In language learning, the presence of errors in student-generated speech are beneficial because they show that students are testing and refining their skills by taking steps to use the language in new and perhaps uniquely individual ways rather than simply mimicking what is written in the textbook or endlessly repeating stock phrases. This type of risk-taking should be supported (see Integrate Risk-Taking and Rewards). When mistakes are made, the teacher should reassure students emphasizing that they did a good job of expressing their ideas along with fulfilling a basic requirement of communication: “understandability.” The teacher may then restate the concept in a grammatically correct or simplified form as a guide (see Modeling) that will help to reinforce proper usage until the time comes to focus on the specific grammatical structure that contained the error. Teachers need to adjust the lesson difficulty allowing for errors to challenge students to

maintain interest but not so much as to be overwhelming. Maintaining a proper balance keeps students interested and fully engaged.

5. Teachers As “Choice Architects”

Thaler and Sunstein explain in their best-seller, *Nudge: The Final Edition*, that when someone is able to influence another person’s choice, they can be called a “choice architect” and engage in “choice architecture.”³ A simple example of this is in the arrangement of products on supermarket shelves where items prominently displayed are more likely to be bought. This is a “nudge” where a person is not directly instructed to choose a particular item but is gently persuaded, or nudged, to choose one over the other. Although the authors apply this concept specifically to economics and to certain aspects of the political and social domains, teachers may also be categorized as choice architects because they can provide nudges to help students arrive at the correct answer or to make a correction when a mistake is detected. These teacher-directed nudges are more effective than simply stating the right answer or making the correction for the students.⁴

Thaler and Sunstein make it clear that coercion or false choices should never be used (except to prevent harm), but soft nudges can be employed to steer people in a more beneficial direction while avoiding restriction of choices that limit the freedom for each individual to choose according to their unique preferences. This is precisely what teachers should aspire to in their correction of mistakes in class lessons. When people are steered away from danger or harm, Thaler and Sunstein have chosen the term “libertarian paternalism,” defining it as “offering nudges that are most likely to help and

least likely to inflict harm” (91). In the English class, the “harm” would be making students feel incompetent or not as intelligent as their classmates and not encouraging students to arrive at the correct answer on their own. Discreet teacher-guided nudges serve to preserve originality adding to student confidence.

6. Integrate Risk-Taking and Rewards

Anabel Gonzalez, who is a member of the Center for Teaching Quality Collaboratory and has studied how errors relate to learning in the second language classroom, responded to Larry Ferlazzo’s question by saying that “error correction is a double-edged sword. Correcting for perfection can stifle fluency and cripple motivation. Yet, in order to strive for growth and improvement, we must be able to seek and identify errors, not shun them” (Response from Anabel Gonzalez par. 9). Teachers should be especially careful not to discourage risk-taking in the classroom by inadvertently creating an atmosphere where students feel they are continually being scrutinized and judged. Similarly, students should not be conditioned to constantly judge themselves in terms of right and wrong which can inhibit them from talking freely when practicing conversational skills and miss out on the all-important error-processing of identify (errors), correct, and learn.

According to Claudia Wallis, Leah Alcala, a math teacher in Berkeley, California, relates how she succeeded in getting her students to be less judgmental: “By taking the grade off their test I thought they might spend more time looking at what they got right and what they got wrong. I wanted to refocus them on actually learning the content” (par. 24). Dehaene concurs with this

strategy by making it clear that error correction should not in any way be seen as punishment, especially singling out grading as an imprecise and predominantly detrimental method of providing error feedback since it is perceived, whether intentionally or not, as a form of reward and punishment.⁵ Another well-known effect of testing is that students are inclined to concentrate solely on “rightness” and “wrongness” by simply memorizing answers without assimilating the information. This judgmental mindset can obstruct the flexible thinking that underpins the creativity of risk-taking.

To further encourage risk-taking, teachers should take many opportunities to offer praise as a reward to expedite learning. Rewarding students stimulates dopamine release in the brain that is critical for learning.⁶ Receiving a good grade on a test might be considered a reward, but since testing is high stress and because students do not always achieve the hoped-for grade, it is not a good fit for that purpose. The better option is to choose less demanding and unconditional forms of reward. It is requisite that students feel comfortable in their environment (the classroom) to be able to experiment with the unique properties of the foreign language without the fear of producing mistakes and being reprimanded or punished, or otherwise made to feel incompetent or foolish, because of them.

Students who are unwilling to take risks in an attempt to avoid making mistakes may not receive enough stimulation which can inhibit their motivation to improve their speaking skills. Studies have shown that risk-taking students outperform and learn better than risk-averse students who prefer to stay within their comfort zone by steering clear of the unknown or avoid confronting new

problems that are likely to be the cause of mistakes.⁷ Like rewards, unexpected mistakes stimulate dopamine release that intensifies interest and boosts learning. Risk-taking students tend to feel less restricted in their thinking which leads to more creative and original language use providing learning-critical stimulation.⁸

6.1 Incorporate Guessing

According to the historical Rescorla-Wagner theory in neuroscience, the process of making a projection and then being surprised to find that it is wrong is critical for learning. The stimulus provided by being surprised causes people to work out why they were wrong and then to adjust their projections to prevent causing future problems – thus zeroing in on accuracy. Rescorla-Wagner conclude that “Organisms only learn when events violate their expectations” (75).⁹ Dehaene takes this concept and translates it into the axiom that “the brain learns only if it perceives a gap between what it predicts and what it receives. No learning is possible without an error signal . . . In other words, surprise is one of the fundamental conditions of learning” (201).

Teachers can make constructive use of this principle by incorporating guesswork into the lessons to condition students to be comfortable with taking risks and alleviate the fear of being wrong or making mistakes. A guess, by its very nature, does not put much pressure on the students to get it right (it’s just a “stab in the dark”) and can be done in a light-hearted fun way. Any guess is good in so far as it provides an opportunity to discuss why it hit or missed the mark and allows students to delve deeper into the thinking process that led to the wrong answer to improve their understanding and accurate use of the language.

To encourage guessing, all answers should be recognized as meaningful attempts to communicate, and corrections made smoothly, so students do not develop a reluctance to answer when they are unsure whether they are right or not. Incorporating responses, whether correct or incorrect, into the lesson and providing more detail (when appropriate) by explaining the target structures (i.e., the responses the teacher was aiming for) help students feel that their attempts had good value and provide a more thorough learning experience for the entire class. Youki Terada, an editor for the website Edutopia, says this about the importance of guessing: “Look for ways to incorporate guesswork into your teaching—getting students to answer questions will help boost their memory more than if they attempt to memorize the material” (par. 9).

6.2 Reinforce the Playback System

Another concept to develop to increase students' comfort level with taking risks is the internal playback system. When speaking, whether as a native speaker or a second language learner, most everyone has a kind of playback system running in the back of their mind as they talk that reviews what they just said to check for mistakes in their message. This process makes it possible for people to catch themselves in a wrong usage or to discern how a previous utterance might have been better stated to support proper understanding. People often repeat themselves, self-correcting as they continue talking to ensure the listener is able to accurately follow along, but it is easy for this playback system to break down when the speaker is under stress while struggling to get an idea across in a foreign language.

Making students aware of this predominantly subconscious system and incorporating it into the lessons can be a very useful teaching technique. It relieves the pressure on students to always get their speech perfect on their first attempts. Mistakes that occur can be accepted as a natural and normal part of conversation without the fear of seeming to be inept. To develop accuracy of the playback system early in the language learning process, “old school” techniques such as repetition and dictation can be practiced. Having students repeat or write down what they heard or said will develop this skill and is one of the methods used when correcting errors (see Echoing). An added advantage is improved concentration in active listening exercises.

7. When to Correct

The teacher must decide how, when, and to what extent a correction should be made. Correcting too often and being too severe may stifle initiative causing students to become risk-averse in trying to work out new and different ways to express themselves. Not all errors need to be elaborated, especially when the focus is on communication. It is sometimes best to casually emulate the correction and let the students know that the sentence or phrase used was a non-standard form or was grammatically incorrect, but since the meaning was clear, which was the objective, the correct form will be practiced in a future lesson.

To determine when and how to correct an error, the following points should be taken into consideration: whether (1) it is a simple mistake, such as an unconscious slip, or due to limited language ability, (2) it is directly related to the lesson or area of speech currently being studied, (3) it

interferes with the thought or idea being expressed. The most urgently constructive amendments have to do with correcting mistakes (defined as relating to something the students have studied and already know), or mistakes that are directly connected to the day's lesson. These mistakes should be amended promptly by providing clarifying feedback and further illustrated to help them sink in.

Correcting errors (related to something students have yet to learn or study) are not as immediately necessary (beyond modeling the correct forms). If an error interferes with communication, the thought should be restated by the teacher to make the meaning clear, but it does not need further elucidation when the language level of the class is insufficient, or if it would be too disturbing to a speaking activity. These errors can be addressed at a later, more suitable time when students are better able to assimilate the corrections. However, an ongoing record of the errors should be kept, especially if they come up often, for the purpose of conducting designated lessons to intensively study those particular elements of the language (see Designated Lessons Using Errors).

8. Correction Methods

Methods and teaching practices have a huge impact on how well students learn. After much research and analysis of decades-long studies, Stigler and Hiebert, in their book *The Teaching Gap*, conclude that methodology plays a central role in the quality of education. While acknowledging that a teacher's level of competency and aptitude are influential, they assert that employing effective teaching methods predominate to maximize learning.¹⁰ Their analysis reveals that inferior

teaching methods are limiting to teachers who can dramatically increase the effectiveness of their lessons and their students' learning potential by implementing the best methods – which certainly pertains to methods of correction as well.

When deciding on a method, the teacher should have a clear objective in mind, and choose the correction method that both meets the objective and best suits the level of the class. The methods that use self-correction are generally preferable to other methods because students are required to apply what they know and tackle problem-solving for themselves. Compared with teacher-provided corrections, students who self-correct expend more effort to identify the faulty thinking process that led to the mistake improving comprehension of the material. Proponents of self-correction believe that this review and modification of the thinking process accelerates deeper understanding of the targeted structures. However, whether studies conclusively show that student self-correction is always superior to teacher-correction is controversial. As a way to address this conflict many educators favor a combined approach to strive for the best outcome. Students can be urged to find mistakes on their own, but with guidance and monitoring from the teacher to ensure success and to check for accuracy (and as an opportunity to offer more dopamine-producing motivational praise).

When explaining the reasons for why an answer is wrong, it is best to address the entire class to avoid singling out any one student for correction that may cause embarrassment and erode confidence. The classroom environment should put students at ease so they do not refrain from trying to use the language in unique ways or eschew speaking for fear of making what might be regarded

as foolish blunders. Teachers may try out various methods and settle on the ones that are a good fit for the class as the instructor gets to know the class level and abilities of the individual students better.

8.1 Test Review

Since making mistakes and then understanding why they are mistakes through teacher feedback is an effective way to learn new material, exams can be used to facilitate the process when used as a learning adjunct in a non-judgmental way (by taking the grade off the test) rather than strictly for evaluation and assessment. The review of exams is best conducted by giving the answers soon after the test and explaining the ones requested by the students (the reasons for why certain answers are considered better than others). This procedure of review and analysis is also a good way to spot the areas in which students are having trouble.

Extra care should be taken when using tests. Where some students may be motivated to try harder, other students with low scores may feel self-conscious about their abilities potentially lowering confidence causing a reluctance to speak up or volunteer information during oral activities. When used prudently for purposes other than assessment, however, exams are an excellent resource for error correction and become a powerful learning strategy.

8.2 Echoing

A common category of error correction is called Echoing. Methods of this type are based on repetition of the sentence that contained the mistake. The preferred method is to simply ask students to repeat what they said. This method is recommended if the students are at a high enough level where they can repeat the sentence, and by

doing so, notice the mistake. This process both reinforces the double-checking of the internal playback system and gives students time to find the problem and self-correct promoting learning and assimilation.

If students are unable to repeat the sentence, the teacher may provide help by repeating the sentence up to the mistake to clue students into noticing the part that needs to be modified serving as a kind of external playback mechanism to assist the students' internal playback loop that might not be fully developed in the foreign language. If it is a simple slip, students should be able to quickly realize that they used the wrong word or grammatical form and make the correction. Alternatively, the teacher may repeat the entire sentence placing emphasis on the misused word or phrase to bring attention to the mistake.

8.3 Visual Cues

Another category for error correction is the use of visual cues to make students aware of missed or misused words. The teacher may show where a missed word belongs by repeating the sentence while counting on their fingers. Sometimes a teacher will use hand gestures or facial expressions to indicate that something is off, or they may devise their own original sign that students begin to recognize. These tactics, like those in the previous section, have the advantage of not directly providing the correct word or grammatical form, or telling students what was wrong, but encourage them to review the sentences while attempting to find the mistake on their own.

8.4 Questioning

Asking questions that bring attention to mistakes are an effective way to point them out. If a student is having difficulty finding or noticing a mistake, the teacher may ask the student a direct question to draw attention to it. For example, if a student says, “I go shopping yesterday,” the teacher may ask (to confirm as though they did not hear clearly), “When was the last time you went shopping?” and the student is instructed to answer in a full sentence such as, “The last time I went shopping was yesterday.” Or the teacher may ask, “Did you go shopping yesterday morning?” and the student may respond with, “Yes, I went shopping yesterday morning,” or, “No, I went shopping in the afternoon.” Depending upon the class level, the teacher may ask for more information that reinforces the correct form such as, “Who did you go shopping with?” and the reply may be, “I went shopping with my friend.” In this way, the process of answering a guiding question focuses students on the proper form and clues them into making the connection to their previous sentence that contained the mistake while making good use of the arguably more effective learning mechanism of self-correction.

8.5 Modeling

Modeling is perhaps the most common method of correction. The teacher uses the original sentence produced by the student and repeats it back in the (grammatically) correct form. When reinforcement is necessary, the student may be prompted to repeat the sentence after the teacher. For more intensive practice, depending on the relevance of the comment and time available, the teacher may have another student, or the entire class, repeat the sentence(s) and then explain the correction. As

always, it is a good idea to emphasize that the error did not interfere with communication (since the teacher was able to grasp what was said and model the correction) and instead treat it as a minor error that produced a desirable result.

Modeling is quick and simple, but it may be the least effective method for learning from mistakes because the corrections are provided by the teacher (a passive, non-stimulating intervention) as opposed to other methods where students are required to actively find the mistakes for themselves. However, if an error is of the kind that is above the students’ skill set (has yet to be studied), or when stopping to analyze a mistake is too intrusive to an ongoing conversation, then modeling may be the better method.

9. Designated Lessons Using Errors

Lessons reserved for the specific purpose of analyzing errors are particularly useful to help students internalize the principles and structures that are commonly misused as noted by the teacher in previous lessons. Teachers may resort to practicing proper usage by including short activities and exercises in their standard lessons – mainly as a way to save time in an already overloaded schedule. However, designated lessons that focus exclusively on the troublesome errors are most instructive since students need to think systematically about the errors helping the revisions to stick in long-term memory. These techniques are used in lesson format because they are not suitable as immediate correction methods during a communication-based session due to the disruption to the flow of conversation.

When engaging students in these remedial lessons and exercises, the ultimate purpose must be clearly stated. Students learn best when they not only know what they are required to do, but when they also know *why* they are engaging in an activity and what they are expected to get out of it to improve their ability to use the language for effective communication. Too often students simply try to get through exercises as quickly as possible and mistakenly believe that since they could breeze through the tasks, the exercises were below their level of proficiency and as a result did not gain much from doing them. Clearly explaining not only the process, but also the reasons behind them including the expected benefits, help students to work through the exercises with more focused intent and serves to limit careless mistakes. Thus, preparing for the activities with a clear explanation directs students to pay special attention to the targeted aspects of the language and to concentrate on using the correct forms as opposed to doing them quickly and often “mindlessly” without benefiting from the learning opportunities incorporated into them.

The following error correction methods are utilized as stand-alone lessons that require students to spend time examining and even playing around with errors while working out why they are wrong. Having previously exposed students to the relevance (and fun) of guessing and risk-taking ensures more active participation and can be integrated into various exercises throughout the lesson for further practice and reinforcement. Designated lessons are concentrated opportunities to spur students into thinking more deeply about mistakes, how and why they arise, and to better learn from them so they do not repeatedly occur.

9.1 Display and Explain

If students are struggling to accurately use certain aspects of the language and the same mistakes are showing up regularly, it may be best to write the sentences or specific forms on the board and underline the errors. While working in groups, students are then encouraged to suggest corrections (even making frivolous guesses) and the teacher records their attempts, eventually displaying the correct form for the class to make note of. This has the advantage of conveying the corrections to the entire class in an easily understood and retainable form and takes the pressure off any one student since the class is addressed as a whole after the common error has been identified by the teacher. Explaining why the attempts were wrong or right enhances the learning process. As noted, this method can be quite disruptive to conversation and therefore it is best to use as a stand-alone lesson rather than spending time on it during an information exchange or question and answer session.

9.2 Brainstorm Mistakes¹¹

Another method for using errors as the basis for designated lessons is to ask students to produce plausible mistakes in answering a specific question that might come up on a test or in a conversation. When making a multiple-choice test, teachers try to list several wrong choices, called distractors, that resemble the correct answer to challenge the students. Using this concept, students are instructed to propose distractors of their own for a specific question, either working in groups or alone, and the ideas written on the board. Students may suggest distractors that they think might be right, or believe to be wrong, but do not fully understand why. This is

an ideal opportunity for the teacher to receive feedback on what areas students are having trouble, and to explain in more detail why the answers produced by the students would be considered wrong (or right) on a test.

A similar approach is to have students split into groups to determine which one of the distractors listed on the board is closest to the correct answer. This compels them to think extensively about the patterns of the language and discuss using higher-order thinking skills to understand and solve a problem. Lessons of this kind allow for more deliberate use of the target language requiring students to expend more effort making the material more interesting and therefore more easily retained and recalled.

10. Conclusion

Errors are indispensable for learning and offer exceptional teaching opportunities when strategically incorporated into English language lessons. Instructors should choose appropriate methods of correction based on the distinction between mistakes and errors in accordance with student ability. Corrections should be made matter-of-factly so students do not feel slighted for making an error and allows for the possibility that the mistake was simply misspeaking that naturally occurs in conversations helping students to feel comfortable in the classroom and not shy away from risking mistakes. Corrections should be made smoothly and swiftly during a speaking activity and the use of detailed corrections well-timed so the flow of conversation is not disrupted.

Miriam Clifford, who holds a master's in teaching from City University of Seattle, has this to say about

teachers and students when confronting errors: "Half the battle is realizing that errors can be used as learning tools. The other half is learning to use them correctly. Mistakes can work to our advantage. Some students resort to memorization, rather than risk making errors. But something is lost if education does not allow students time to try things on their own" (par. 4). The takeaway is that teachers should not be "mistake-averse" to the errors students make in the same way that students should not be risk-averse to making them.

Notes

1. Stanislas Dehaene has extensively studied how the brain learns new information using the latest advancements in neuroscience. Throughout his book, *How We Learn*, he explains the importance of mistakes in learning and specific references can be found on pages 203-205.

2. See Dehaene's discussion of attention and active engagement in Chapter 7 (pp. 147-175) and Chapter 8 (pp. 177-197) respectively.

3. For a summary of this concept, see the Introduction on pages 3-18 of *Nudge: The Final Edition* by Thaler and Sunstein, and for a more detailed discussion on how these terms are applied see Chapter 5 (pp. 103-129).

4. In her article, "Learning from Errors," Janet Metcalfe of Columbia University cites research that shows students learn better when they are not pressured to avoid mistakes, but instead encouraged to attempt an answer, review the mistakes spotted, and make corrections themselves.

5. See Dehaene's insightful discussion of grades on page 211: Grades, A Poor Substitution for Error Feedback.

6. Numerous studies show how dopamine greatly benefits learning. For a brief discussion of this effect, see the article on the Michigan News site: "Dopamine: New theory integrates its role in learning, motivation," and the blog on the 360Learning site: "The Link Between Dopamine and Learning Outcomes: What Does it Mean for Business?" by Amanda Rollins.

7. A couple of accounts that show this connection can be found in the following article by L. Suryani and N. Argawati "Risk-Taking Students' Speaking Ability: Do They Correlate?," and "Does Learning Require Taking Risks?" by Chris Loper.

8. In his article, "Why Taking Risks is Critical for Creativity," Anthony Fredericks, Professor Emeritus of Education at York College, argues that mistakes are good for learning due to the powerful impact they have on stimulating creativity.

9. By conducting numerous studies on animals in their ground-breaking study "A Theory of Pavlovian conditioning: Variation in the effectiveness of reinforcement and nonreinforcement," Rescorla and Wagner reached the conclusion that better learning takes place when failure to produce a predicted outcome resulted in surprise providing a strong impetus to make a correction and retain the information to prevent future failures.

10. With the aim of providing concrete suggestions for improving the quality of teaching in U.S. schools, Stigler and Hiebert base their research

on the results of the Third International Mathematics and Science Study that compared teaching practices in American schools to those in Japan and Germany. On page 10 of their book, *The Teaching Gap*, they make the assertion that method trumps teacher competence.

11. The methods presented in this section are condensed from the article "The Magic of Mistakes: 4 Ways to Boost Critical Thinking with Mistake Analysis" by Colin Seale, founder, and CEO of thinkLaw.

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