

The Influence of Task Difficulty on Engagement, Performance and Self-Efficacy

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Abstract

My research examined the impact of a person's belief about their own capabilities and how this influences their performance. In order to examine this I needed a task that was both relatively enjoyable, so that participants would engage with it in their own free time without pressure to do so, and a task that was not heavily linked to a particular subject as this would influence performance. That is the line of thinking that led to a PhD examining self-efficacy theory by getting hundreds of children to play Pacman, a popular arcade game.

Author Biography

I have designed and delivered multiple initial teacher education modules dealing with many aspects of technology education. I have also designed and delivered multiple engineering education modules typically designed adhering to CDIO standards. I am currently working as part of a large team examining spatial and mathematical skills, and based in Michigan Technological University.

The questions I asked and why I think they are important

As my study grew so too did the questions that I sought to answer. The earlier questions were rather simplistic in nature, but as my understanding of human behaviour and the factors that influence it grew, so too did the nature of the questions.

First I asked how task difficulty impacts an individual's performance? This may seem to have an obvious answer, but often the answers we take for granted are partially, if not entirely, false. As discussed later, difficulty plays a large part in how we see ourselves relative to the activity in question. And how we see ourselves influences everything we do. The delicate balance of an appropriate difficulty level is something that all educators are all too aware of. Too difficult and the student will disengage almost immediately, while on the other hand a task that is too easy is often dismissed as not pushing the student's knowledge in the area forward. But if we take the factor of developing knowledge out of the equation we can get a clearer look at how difficulty is impacting the individual's behaviour. Can a small decrease in difficulty result in a big increase in engagement? Can this increase in engagement make up for practicing with a task that is objectively easier than the final 'exam'?

This led to the question of how reward influences a person's behaviour? If difficulty remains the same for all, could reward alter behaviour? If increased reward could result in increased engagement would it not be a superior way to coax engagement in the desired direction? This question also provided additional perspectives on the difficulty question. Ultimately when an individual engages with an easy task they tend to receive greater rewards, be it a higher percentage in a low level math test or praise from a parent. So if low difficulty results in increased reward how can we say what is due to difficulty and what is due to reward. By examining each in isolation we can begin to form an estimation of each.

These questions in turn led to me asking whether I could cancel out the negative effects of increased difficulty with the positive effects of increased reward. Could I get participants to demonstrate increased engagement with the highest difficulty level? This also provided

another snapshot of how difficulty and reward were interacting with each other. But ultimately the questions so far were not getting to the heart of the matter. I was looking at outcomes, scores, engagement rates etc. But it was clear that it was the way participants viewed their own ability that was the common link between difficulty and reward. This is where I adopted Self-efficacy theory into the study. Self-efficacy is a person's belief in their ability to succeed or accomplish a task in specific situations. A person's sense of self-efficacy can play a major role in how one approaches goals, tasks, and challenges. This led to the final and most important question of the entire study:

How does difficulty influence Self-efficacy?

How I tried to answer the questions

I could say that I earned a PhD in Pacman, or rather by observing how individuals behaved when playing Pacman. This became the defining description of my research for a few years. As a new postgraduate student you tend to go to great lengths to impress the very important professors around you, and it is common practice to attach overly complicated names or descriptions to simple concepts. It was in this manner that I referred to Pacman as a "digital maze navigation task" for my first two years. But I will explain why I believe Pacman, a popular arcade video game (See Figure 1.) was an ideal platform for examining the role of difficulty, reward and self-efficacy when looking at behaviour.

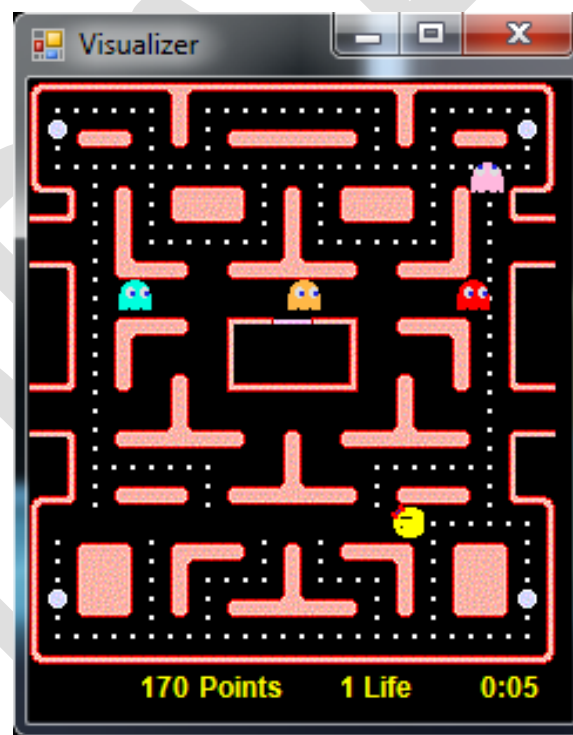


Figure 1. Computerised Maze Navigation Task

When I set out to examine the influence of difficulty I was originally going to use math tasks. However there were multiple problems with that idea. People have wide ranging levels of ability when it comes to math. They have a considerable amount of baggage, both good and bad, and most children that I know would not engage in extra math of their own free will. So I needed a task that did not draw heavily from previously learned skills, that did not come with considerable previous experience and that was reasonably motivating. On top of this, the task needed to be able to facilitate various subtle manipulations for the purpose of an

experiment. Pacman satisfied all of these requirements and also promised to greatly aid participant recruitment. By slightly altering the games code different properties could be altered to increase or decrease difficulty or reward.

Over the course of 4 rounds participants played Pacman during a school week on their personal USB version of the game. This USB recorded date, time and score whenever it was used. At the start of the week each participant would play a standard version of the game (to gauge initial ability level) and again at the end of the week (to gauge improvement). What the participants did not know is that they had been given one of three versions of the practice task with a subtle manipulation of either difficulty or reward based on the round. The final round added a Sources of Self-efficacy scale to examine how these hidden variations in the game were affecting their beliefs surrounding their capability for the task. The completed study involved over 240 students who were all in their first year of second level education (Mean age 12.4 years).

What I found out

The early rounds of the study addressing the impact of difficulty on overall performance proved to be very interesting. One might assume that by practicing all week on the highest difficulty level that when the participant sat the final 'exam' using a comparatively easier task that they would perform better than their peers. This however proved not to be the case. Those who practiced with the highest difficulty consistently performed worse than the group that practiced using either the easy version of the task. Next came the medium difficulty group and finally, with the highest score, the group that practiced with the low difficulty version of the Pacman practice task.

The impact of difficulty, that very obvious question I asked earlier, proved not to be as straight forward as I had expected. In order to explain the difference in scores I examined the data stored on the USB sticks. When the amount of practice attempts was calculated per difficulty group a clear pattern emerged (See Figure 2). Those who practiced with the highest difficulty level practiced the least amount of times in the first day and this pattern continued throughout the practice period. Any benefit they might have gained by practicing with a task that was more challenging than the final 'exam' was completely overshadowed by the benefit of practice. With those who practiced with the easy version of the task the opposite was true. Whatever disadvantage this group may have suffered by practicing with a task that was less challenging than the final 'exam' was completely eclipsed by the benefit of increased engagement with the practice task.

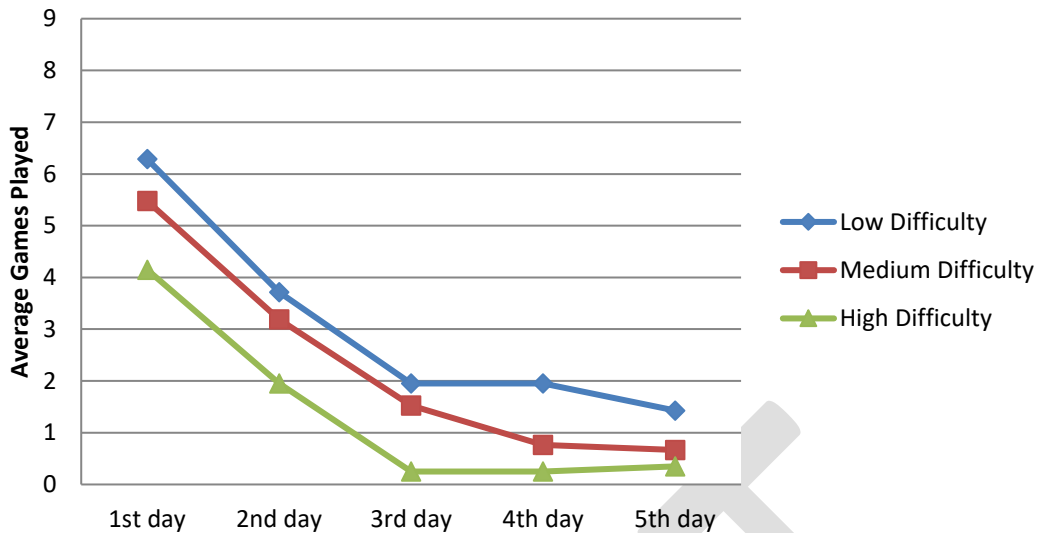


Figure 2. Manipulated Difficulty Engagement Rates

This suggested that difficulty was impacting something deeper, altering something that went beyond simplistic models of behaviour. This led to the question of how varying reward would influence performance. This time participants practiced with a high reward, medium reward and low reward version of the task. The reward was the amount of points they received for each power pill they collected in the game. Once again participants were unaware of these hidden variations.

This resulted in patterns that you would expect. The high reward group showed greater engagement and overall performance while the low reward demonstrated the lowest rates of engagement and performance. However the differences between groups were far smaller than those observed in the difficulty variation round suggesting that reward was not as big a factor as difficulty. In order to further examine the influence of difficulty and reward a further round was designed. In this round the task was manipulated to see to what degree the positive affects of increased reward could offset the negative affects of increased difficulty. Rather than one negating the other a different pattern emerged.

The expected pattern was the high difficulty being dragged up by the high reward and the low difficulty being dragged down by the low reward. This however was not the case. All groups showed much greater improvements than those observed in previous rounds. While overall the low difficulty group still improved the most, and engaged with the practice task the most, the high difficulty/high reward group scored higher than any group in the previous round. All groups practicing with this proportional reward version of the task scored far higher than their peers in previous rounds. This suggested that difficulty and reward were interacting with each other. At this point in the study it was clear that something far more complex was happening than individuals simply reacting to variations in the task. In terms of psychology, the study to this point could be said to be operating under a behaviourist approach. Behaviourism attributes changes in behaviour almost entirely to environmental factors. It is also concerned almost exclusively with observable events. If the study was stopped after the first two rounds then we could satisfy the earlier questions by examining them in this manner. Difficulty was altered (environmental factor), this impacted engagement (observable event) and this impacted performance (observable event). However this failed to explain multiple points that had arisen throughout the study. Why had lower difficulty resulted in increased engagement? Why had reward and difficulty interacted to produce such a large increase? These questions

could not be satisfied within behaviourism, thankfully a much clever man than I had encountered a similar problem over 40 years before.

When Albert Bandura created Self-efficacy theory it was in response to what he saw as the short comings of behaviourism. He believed that humans were much more complex and that something else was happening when we altered our behaviour. Where behaviourism was only concerned with the interaction between behaviour and the environment, Bandura thought that an additional factor was at play, namely cognition (Fig. 3).

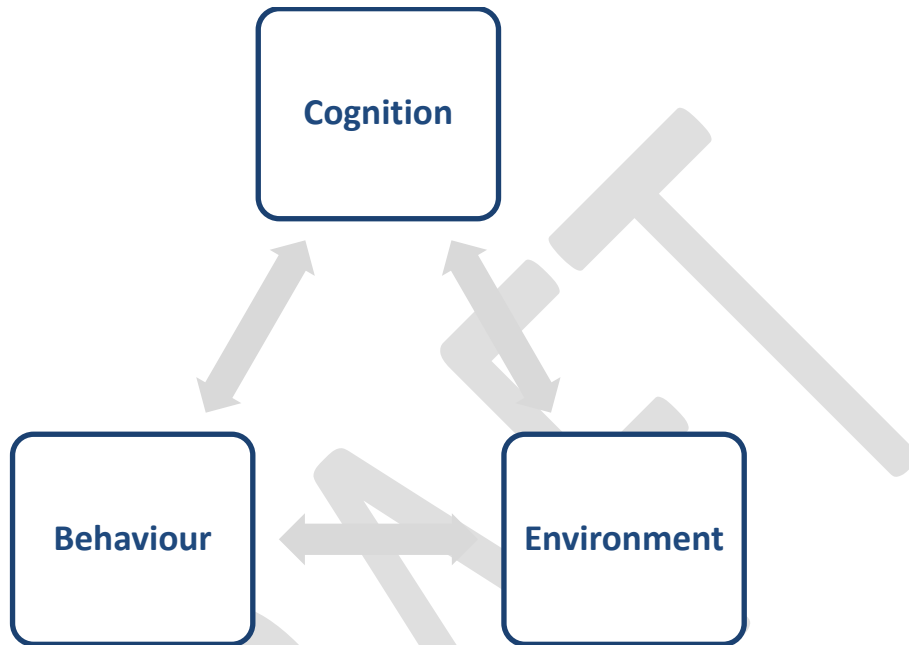


Figure 3 Bandura's Triadic Reciprocity Model

Bandura's earlier work in Social Learning Theory examined how cognition influenced behaviour, he called this Triadic Reciprocity. His additional factor in the model stressed that there were many internal factors (cognitive skills or attitudes) that influenced behaviour. But just as cognition could influence behaviour (i.e. I believe I can so I do) so too can behaviour influence cognition (i.e. I did before so I believe I can). Environment could also impact behaviour, as we saw in previous round, but could also influence cognition. It is within cognition that we can picture a person's self-efficacy, their belief in their ability. When considering the influence of self-efficacy (cognition) on performance in Pacman (behaviour) we could yet again class it as having an obvious answer. But if you have been paying attention so far you may have spotted that all of our obvious answers have proven to be false. Much of the current research examining self-efficacy and performance has stopped at the obvious. They have looked at how high levels of self-efficacy predict high performance but that only tells part of the story. Does simply having an increased sense of your own ability lead to success?. So why were individuals with increased self-efficacy performing better? Could self-efficacy be manipulated in order to increase performance? In order to gain a better understanding of the influence of self-efficacy a final round was designed to answer the question: *What is the relationship between difficulty and self-efficacy?*

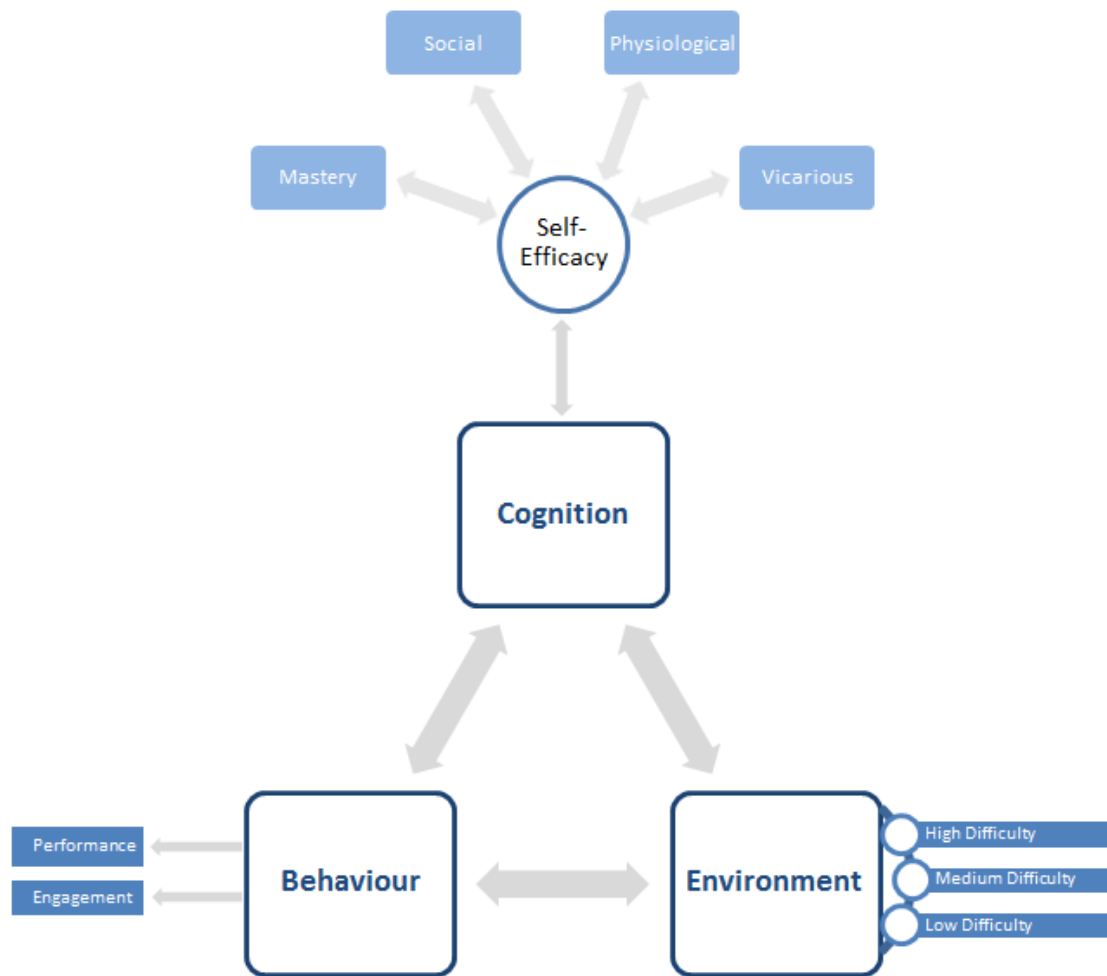


Figure 4. Title

The model above in Figure 4 shows how self-efficacy could interact with cognition and fit into the triadic model we looked at previously. Also shown are the four sources of self-efficacy as theorised by Bandura. Individuals draw from these informational sources in order to create their sense of self-efficacy for a given task. Mastery refers to previous positive outcomes in a similar task. Social Influence refers to information drawn from people around the individual. For example positive or negative feedback from a peer, a coach, a parent etc. Physiological refers to information drawn from your own physical state. For example rapid heartbeat or sweaty hands before a presentation. Vicarious refers to observing an individual who you feel is close to your level of ability completing a similar task successfully. For example Mary solved the math problem and I am about as good at maths as she is. In order to examine this interaction a final round was conducted.

In order to measure self-efficacy participants completed a Sources of Self-efficacy scale after their first game and just before their last game, a selection of example items from the scale are included in Figure 4.

6. I do well on even the higher levels of Pacman										
Strongly Disagree										
1	2	3	4	5	6	7	8	9	Strongly Agree	

7. Seeing others do well in Pacman pushes me to do better										
Strongly Disagree										
1	2	3	4	5	6	7	8	9	Strongly Agree	

8. When I see how others win a game, I can picture myself winning the game in the same way										
Strongly Disagree										
1	2	3	4	5	6	7	8	9	Strongly Agree	

Figure 4. Example of Self-efficacy Scale Items

In this round they practiced with the hidden difficulty variations only. Previous patterns of engagement and performance were repeated with those practicing with the low difficulty level scoring the lowest and those practicing with the high difficulty levels scoring the highest. However the data from the sources of self-efficacy scale presented a potential explanation for the bigger question, why? The lower difficulty lead to increased engagement, which has been observed in previous rounds. But it also led to higher levels of mastery experience (claimed to be the most powerful source of self-efficacy), vicarious experience and physiological state. No meaningful change was observed in the physiological source, this source has proven difficult to examine reliably in many studies. Ultimately this final round led to some important conclusions. Self-efficacy could be manipulated by difficulty. It aligned with positive outcomes such as increased engagement and perhaps most importantly highlights the impact of a tasks design on how a child views their own capability.

How this might be used to improve teaching and learning in terms of:

Overall curriculum planning

The impact of what we know about self-efficacy development, in relation to curriculum planning, reflects educators' continuous efforts to differentiate within classrooms that often cater to a very wide range of ability. In many ways it reaffirms pedagogical best practice from a psychological perspective; while also offering insights into how to further utilise this positive force. Fundamental to self-efficacy development is the possibility of success. If a student believes that failure is inevitable they will disengage from the task. With this in mind it is vital that more complex concepts are scaffolded in such a way as to provide opportunity for success early in the student's first encounter. This should not be confused with simply lowering the overall difficulty or complexity of the curriculum. Rather it is an opportunity for the student to experience mastery, the most potent source of self-efficacy, at an early stage. This reduces the likelihood of disengagement and provides an opportunity for the student to develop a sense of competency relative to the task at hand. In this manner a student's sense of self-efficacy can be increased in line with the difficulty and complexity of the curriculum over time.

As mentioned previously this aligns with the widely employed practice of differentiation in the classroom. While the importance of differentiation is widely acknowledged (Tomlinson, 2003), poorly designed educational systems can hamper educators ability to apply these practices in the classroom (Hertberg-Davis, 2009). This highlights two key issues that must be addressed. First educators should be involved in the design of new educational structures such as curriculum, or must at a minimum be afforded the professional autonomy to select their own differentiation techniques in a classroom. Secondly it is important that designers of

these educational systems are aware of the potential debilitating effects that early and repeated failure can have on a student's self-efficacy. This is especially true for students who are most at risk of dropout and underperformance (Caprara et al., 2008). In addition curriculum designers should be aware of the influences of social persuasions in the development of self-efficacy.

Social persuasions, in the form of feedback from peers, parents and teachers will influence an individual's self-efficacy and curriculum designers can take considerations that will facilitate the engagement of this source. Inclusion of project based learning provides a useful medium for exploiting this source. The conclusion of a project, or a part there of, provides an opportunity for critical feedback from a variety of sources. In order to amplify this effect a designer can facilitate structured feedback systems so that peers provide meaningful feedback as opposed to simply praising the individual. As previously discussed, praise should not be confused with critical feedback. Critical feedback will focus on successful outcomes and will tend to be domain specific, this is of much greater value in terms of self-efficacy development. Conversely praise will tend to focus on an attribute of the individual that may have little to do with the domain in question.

Similar considerations can be taken if blended or online learning environments are to be used. Evidence suggests that increased dropout rates and poor engagement rates in online and blended learning environments is linked to self-efficacy (Bates & Khasawneh, 2007; Lee, 2015; Wang & Newlin, 2002). Researchers have identified many different ways in which self-efficacy can influence behaviour in these learning environments. One impediment is low self-efficacy for using the online medium in question. This specifically relates to students beliefs around their ability to effectively use the online learning systems. This highlights selecting systems that are age appropriate and user friendly. If advanced systems must be used then adequate training and support must be provided if students are to reach the learning goals that drove the selection and inclusion of the medium. In addition to this barrier the problem of reduced social interactions in online learning environments has the potential to limit self-efficacy formation for learning. Self-efficacy for learning specifically relates to an individual's belief in their ability to learn the current topic. As you might imagine this is domain specific. For example my self-efficacy related to my ability to learn linear algebra is vastly different from my self-efficacy for learning French. Lower social interactions can reduce availability of relevant information from the social persuasion and vicarious experience sources. This can also hamper mastery source input as students often judge success in a task by comparing performance to peers if clear success criteria are not provided.

However the typical classroom use of online platforms more closely resembles a blended learning approach. This is advantageous for a number of reasons. Educators can assess students capability in terms of using the online system in person and provide additional guidance if necessary. Educators can also facilitate feedback, and peer interaction, in the classroom negating the previous drawbacks of purely online learning environments. You may have noticed that self-efficacy development seems to focus heavily on social interactions. This reflects its origin from Bandura's Social Cognitive theory. Ultimately judgements surrounding our own competence is entirely dependent on context and comparisons. It is important for curriculum designers to facilitate practitioners in employing strategies that use this knowledge increase student development and learning outcomes.

Assessment for learning

As mentioned previously an individual develops their sense of self-efficacy by drawing on 4 informational sources (Mastery, Social Persuasions, Physiological and Vicarious). The

manner in which an individual is assessed will have a significant impact on these sources. Mastery in particular cannot be simplified to a high grade or a level that the teacher may deem successful. Rather it will depend on the individual's perception of their performance. For example a student who typically receives D grades could deem a B to be a successful outcome, in this scenario the B grade becomes a useful source of mastery. Whereas a student accustomed to A grades would most likely deem a B to be an unsuccessful outcome.

However more descriptive feedback surrounding how the individual has improved relative to previous performance is a far better source as it combines mastery with the social persuasions source. As an authority figure and expert, descriptive feedback from you as an educator can have a profoundly positive impact on a student's self-efficacy. However it is important to distinguish meaningful feedback from simple positive compliments. Feedback that focuses on elements of the performance and behaviour that resulted in the positive outcomes, rather than the positive outcome itself, ensures that the student attributes the outcome to effort and behaviour which they have control over. This is in contrast to a belief that the positive outcome is simply related to some natural aptitude for the task. Yeager and Dweck (2012) provide an overview of what they refer to as Growth Mind-set, which is relevant when discussing the impacts of self-beliefs in the classroom. In addition it is worth noting John Hattie's influential meta-analysis studies have repeatedly highlighted the considerable impact of feedback on learning outcomes (Hattie, 2013; Hattie & Gan, 2011), with some of his more recent work acknowledging the many different types of feedback and how these can influence the learning process (Hattie, 2015).

Teaching methods in lessons

As noted in previous sections, the decisions that you as an educator make in terms of planning and teaching will have profound impacts on how your students perceive themselves. This in turn will affect behaviour and ultimately learning. Being aware of this impact will allow you to maximise the desired outcomes while simultaneously minimising undesirable outcomes. When designing activities for the classroom an educator should be cognisant of the previously identified factors which will impact student's self-perceptions. Namely structuring difficulty so that students can experience some form of mastery in the early stages but also in controlling how that student comes to judge mastery experiences.

This requires complex topics to be broken down into smaller manageable activities while employing differentiation to increase difficulty on an individual basis. By preparing multiple difficulty levels in advance teachers will allow themselves time to focus in class time to address students who may be struggling. Once a student with low self-efficacy has been identified you employ the social persuasions source as a means of bolstering self-efficacy through targeted feedback. In addition you can employ the vicarious source by pairing a student who is struggling with the current level with another student. This will allow for peer teaching but also provides a chance for the student in question to observe a peer succeeding. It is important that the student considers this peer roughly comparable in order for the vicarious source to be effective. If the student simply believes the other student is naturally excellent then the vicarious source will provide little benefit. Ultimately educators need to be aware of the pitfalls of low self-efficacy more so than the benefits of exceptionally high self-efficacy. Students who believe they have no chance of succeeding in the given task will have poor motivation and can often be a continuous source of behavioural issues. Providing early opportunities for success is more about the impact on future behaviour than the initial comparatively shallow learning outcome.

Other areas related to your research

Self-efficacy is only one of many self-regulation theories. These theories examine how individuals behave and think relative to certain tasks and activities and have been studied in areas as diverse as professional sports, business and lifestyle. The reason I believe teachers should consider these theories when examining their own practice is that research shows that we have a huge impact on how our students see themselves. This is a responsibility that we should not take lightly. It has the potential to increase motivation, self-esteem and multiple desirable behaviors. Conversely, if we act with little regard to the impacts of our professional decisions and actions we risk increasing dropout, disengagement and increasing behavioral issues in our classrooms. It is vital that we as educators appreciate the influence that we have on our students and that the lessons we teach go far beyond the prescribed topics of a subject. Teaching at it's most important level is a profession which aims to develop people. By understanding how people behave relative to your actions you can help to develop behaviors and cognition that has the potential to help an individual in a wide range of areas that go beyond your chosen subject discipline. With that in mind I have found the following texts to be informative, accessible and of practical use for the modern classroom. Artino (2012) provides an excellent overview of self-efficacy theory and it's relevance to classroom practice. Although the paper was written with medical educators in mind I believe it is one of the best pragmatic discussions of the benefits and potential misunderstandings of the theory that has been written to date. For a broader discussion examining the influence of mindsets on students behavior I would recommend Yeager and Dweck (2012). Dweck's work has been hugely influential and her work surrounding Growth Mindset is compatible and complimentary to self-efficacy theory.

What else would be good to know, and how could teachers find out?

Self-efficacy theory belongs to a larger group of theories collectively referred to as self-regulation theories. These theories focus on how an individual exerts control over their own behaviour. For us, as educators, it is hard to overestimate the importance of self-regulation in our classrooms. It impacts how and what we teach, but most importantly it can have profound impacts on the development of the individual child. For example whether a person chooses to persevere or give up after failing at a task may seem like an insignificant act in isolation, but over time can have devastating impacts on a child's educational experience. This is why it is important to examine theories such as self-efficacy, not as abstract works created for their own sake, but as limited glimpses into a an endlessly complex system that influences human behaviour. What I find personally interesting about the research discussed here is the conclusion that we as educators, through the decisions we make and practices we engage in, can alter a student's views of their own capabilities. By extension we can influence how they see themselves as a person. Ultimately I believe this is the most important responsibility of an educator, the personal development of our students. This has many implications for classroom practice. If, as the research discussed here suggests, student's beliefs surrounding their ability have such impacts on their learning why is it that we almost exclusively focus assessment almost entirely on learning outcomes? By extension why not directly target these areas through interventions in our classrooms? An ongoing research project, PERTS (Project for Education Research that Scales), provides accessible research and materials that educators may use in their classroom in order to assess students' beliefs. Perhaps more importantly they outline interventions, that have been rigorously designed and are supported by a considerable body of evidence, that are designed for use in a classroom.

In the previous description of research and its relevance to your role as an educator I focused heavily on self-efficacy, however this is only one theory among many. There are numerous competing self-regulation theories and ultimately it is up to the practitioner to evaluate each (Sitzmann & Ely, 2011). While theories within self-regulation may be described as competing, there are many other educational and psychological theories that could be described as complimentary to self-efficacy. I have previously mentioned Dweck's mindset theory which I believe is both relevant and compatible, but Dweck has also created a very useful overview of self-theories and their role in motivation, personality, and development (Dweck, 2000). If I was to conclude with one message that summarises the previous discussion surrounding research, theory and practice it would be this. You as an educator influence how your students perceive themselves. This can have considerable impacts on student behaviour and development, both negative and positive.

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