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**An analysis of the significance of analogies
and metaphors in education, linking to
experiences in the science classroom**

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Abstract

Analogies and metaphors have a close link into human imagination and have been shown to help increase conceptual understanding of a topic, while also being powerful tools of communication. They are already well used in modern day science to help scientists create models and theories of phenomena that is currently not fully understood. This is particularly helpful in science, where certain concepts can really push human imagination.

In this report, I discuss my use of metaphors and analogies before and during the PGCE course. I believe that all science teachers would benefit by planning to use them in their lessons. The reason for this is that it is my belief that they encourage the student to use communication, lateral thinking, and resilience skills to understand the similarities.

Introduction

In the past, before I started the PGCE course, I used to teach SCUBA diving. One topic in diving that many people seemed to have difficulty understanding is the *tissue compartments* model of the human body. These are theoretical compartments within our body that absorb nitrogen while a person is SCUBA diving, which is the primary cause of decompression sickness in divers. The theory states that some of our tissues, for instance blood, will absorb nitrogen quickly. These *fast* tissues will also release absorbed nitrogen very quickly when the diver is back on the surface. Other tissues, like bone, are *slow* tissues and will absorb and release nitrogen at a much slower speed. There are at least six other theoretical compartments (depending on what variation of the model is being used) equally spaced between the fastest and slowest compartments. Each of these compartments have a different rate of interaction. Some of my student divers found it difficult to understand this concept, until another instructor suggested to me that the best way to explain this was to use an analogy. He suggested imagining that the body was made up of two different types of paper, the thinnest being tissue paper and the thickest being cardboard. If we were to put these underwater, which would absorb the water the fastest? Then if we were to put them on the surface, which would dry the fastest? Of course, the tissue paper would be the fastest, while the cardboard would be the slowest. Now imagine that you would put 6 more types of paper into the body, each gradually increasing in thickness from the tissue paper to the cardboard, and did the same experiment. The way that these different types of paper absorb, saturate, and release water is a good analogy for the way that the theoretical tissue compartments model of the body acts with nitrogen. This analogy really helped my dive students understand this concept, and was the first time that I realised how powerful analogies and metaphors can be to help students gain a better understanding of science. In this report, I will summarise my use of analogies and metaphors during my PGCE training. I will also conduct a critical analysis for current research on this subject, and use this information to suggest future strategies for use in the classroom.

Introduction to analogies and metaphors

Citation

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On occasion, analogies and metaphors are used interchangeably by some authors. In this report, I have followed the example set by Duit (1991). They stated that an analogy is a comparison between two concepts where the similarity is given to the student. A metaphor is a vaguer comparison between two concepts where the basis of the comparison must be discovered by the student. An example of a metaphor would be “A good data-set is a powerful weapon”. The student must be the one to justify why this data-set is a powerful weapon. Duit (1991) states that the element of surprise in a metaphor is what makes it such a powerful tool in teaching.

Metaphors and analogies have a very close link to human imagination, and therefore are very useful in encouraging conceptual understanding of a topic. In my opinion, metaphors have a greater impact on conceptual understanding than analogies, due to the more open interpretation of the metaphors by the receiver. Gibbs and Matlock’s (2006) conducted an experiment where participants were given similar metaphorical or non-metaphorical phrases to look at for ten seconds. An example of these phrases would be “Encourage understanding” (non-metaphorical) versus “Stretch your understanding” (metaphorical). The participants were then asked to form a mental image in their mind of the phrase. The results of this experiment showed that the participants that were given the metaphorical phrases produced significantly more detailed and conceptualised descriptions, when compared to those who were given the non-metaphorical phrases. This would suggest that using metaphors will help engage the brain in a more conceptual way than simple hard facts about a topic. Indeed, it seems clear that when a person wants to emotionally express themselves, they will often use metaphors to do this. Metaphors can clearly be used to help communicate important points that the communicator is expressing. Evidence of this can be seen in the high usage of metaphors used in poetry, song lyrics, and literature.

Analogies and metaphors in science education

In science, it is very common that when something is not completely understood, a best guess theory or model is constructed. A good example of this might be string theory, or dark energy. At this current time, we do not have the technology to fully understand these phenomena. We know what energy is and how it interacts with matter, and we know what strings are and how they can be used to transmit waveforms. We can use this information to create a metaphor or analogy to help us better understand these phenomena. In time, we may find that our model proves to be incorrect and our metaphor breaks down, or that our theory proves to be correct and our metaphor becomes a true description of the phenomenon. For this reason, I feel that the use of metaphors and analogies are particularly suited to science education. There have been times that our models have proven to be correct up to a point, but not fully adequate to gain a complete understanding of the phenomenon. An example of this would be in the wave-particle duality of light. We know that at times photons behave like particles, and other times they behave like waves. We also now know that photons are neither waves, nor particles. They are simply photons. This does not mean that we cannot still use our wave and particle analogy to gain better understanding of photon interactions.

The use of analogies and metaphors in science education has been well documented as being a useful tool in the classroom (Haglund, 2013). The basic idea is that the teacher can help a student learn a new concept by transferring knowledge that they know from another topic into this new concept. This follows the *constructivist* approach to learning, which states that learning is constructed with the use of previously acquired knowledge to understand unfamiliar subject matter. The concept that the student is getting their knowledge from is known as the *source* or the *seed*, while the concept where the student is applying their knowledge, is known as the *target* (Wegner and Nuckles, 2015). A very well-known analogy used by many teachers in physics lessons is between an electrical circuit and water-flow in pipework. The teacher asks the students questions regarding what would happen if they took measurements in a pipework of water. The teacher can then get the student to use this information to predict measurements in electrical circuits. An example may be to

ask the student if the rate of flow would vary at different points in the pipework, then use this information to predict what the current might be at different points of an electrical series circuit. In this example, the water pipework is the source concept while the electrical circuit is the target concept. I have personally used these analogies in almost every lesson on electrical circuits, and found them to be very successful for helping students gain understanding. I have often asked my students to create their own analogies for certain concepts, which has helped me assess their understanding of the topic. If they cannot find a suitable analogy, then it is a good indication that we need to spend more time on this subject. Some examples that the students have given me regarding water analogies of electrical components are listed below:

Table 1: Example of water analogies given by students to help understand electrical components

Electrical component	Water analogy
Battery/Cell	Water pump
Resistor	Tightening of the pipework diameter
Variable resistor	Valve
Electrical lamp	Light powered by water wheel

Metaphors can enhance our understanding in other more formal and logical subjects. A good example of this would be in mathematics. There are times that teachers and students will use metaphors without realising that they are doing this. An example of a very commonly used metaphor would be when the teacher asks the student to balance their equation. The student will usually see that whatever they do to one side of the equation, they will need to repeat on the other side of the equation, like adding or removing weights from an old-fashioned set of balancing scales (Amin et al. 2015).

Analogies and metaphors in the classroom are not without potential negative results for teaching and learning. It is possible that the student fails to see the connection between the source concept and the target concept, or they may use the metaphor or analogy too literally and fail to see where it breaks down in the model (Haglund, 2013). On occasion, I feel like the use of analogies/metaphors can also create misconceptions. I have personally seen this in a year 8 KS3 lesson. I was teaching a lesson on respiration, and trying to explain how the gas exchange of oxygen and carbon dioxide happens by diffusion interactions with hemoglobin. I used a metaphor by explaining that hemoglobin is like a train going around the body and allowing gas to enter and exit at required places. I explained that if there is a lot of oxygen in the alveoli, then when the hemoglobin train arrives at the alveoli station, the oxygen will be forced onto the train due to the high concentration within the sac. I also explained that when the train arrives at the alveoli sac it is bursting full of carbon dioxide, again like a train full of people that need to get off. This was one of the first lessons that I ever taught, and at this moment I feel that I will not use this metaphor again, or if I do then I will have to try to adapt my explanations to make sure that the point I am trying to make is clearer. I found during an end of term KPI exam many of my students wrote in their answers that respiration is a train going around the body, without writing anything about diffusions of gases within the system. It is possible that I did not explain the key concepts or keywords correctly and I focused too much on the metaphor, which might have been the reason for this metaphor not being as successful as I had hoped in helping the students understand respiration.

Analogies and metaphors in teaching and learning

The use of metaphors in the classroom can extend much further than purely being used to help a student understand a new scientific concept. Tobin and Tippins (1996) stated that the metaphor that the teachers say to themselves about their roles as teachers can have a significant impact on the learning and behaviour of the students. The authors state that a metaphor used as a guide for the

actions of an individual is known as a referent. At times, some teachers may see themselves as the “Captain of the ship” and follow an authoritarian approach with their students. The students may potentially respond to this either with submission or rebellion, but they may be more focused on completing large amounts of work due to the fear of future sanctions if not enough work has been completed. Other teachers may use the referent that they are a kind of “Entertainer” for the students, and again the students’ learning and behaviour may be different. The students may achieve less work than the more authoritarian approach, but have a greater conceptual understanding on the subject matter. In my opinion, the best teachers can use a variety of different referents, depending on their required goals for the lesson. If they need to get a lot of work done then using a more authoritarian approach may be the best option, but if the teacher is planning more student led learning then using a more entertaining approach might be a better option. Gurney (1995) conducted research on how teachers view the teaching/learning process. They asked a selection of prospective secondary school teachers to use a metaphor to define their opinion on how teaching and learning takes place. The results showed that some teachers believed that teaching is about delivering knowledge to the student. Some teachers believed that teaching happens when you facilitate growth in the students. Other teachers believed that teaching is about allowing the students to journey through knowledge themselves to gain valued insights. Finally, some teachers viewed it as a personal activity that the student must choose what they feel is important to learn and what is not. The results of Gurney (1995) and Tobin and Tippins (1996) research shows that metaphors can also be used to better understand teaching and learning and therefore can be used as a tool not just within science education, but to better understand the pedagogy of all educational subjects.

Not only can metaphors be used to understand educator’s views on teaching and learning, but they can be used to interpret the students’ understanding of the learning process. Wegner and Nuckles (2015) completed a study where they asked a group of university students to complete a questionnaire. This questionnaire had a list of metaphors relating to learning, including statements like “Learning is like building a library with your own books. You start with one shelf and while you get more and more books you also need more shelves” (Wegner and Nuckles, 2015). They were researching whether students considered learning to be knowledge acquisition, regulation related, problem solving, or personality development. The results of their study showed that most students considered learning to be purely knowledge acquisition. It would be interesting to see whether the results of Werner and Nuckles’ (2015), Gurney’s (1995), and Tobin and Tippins’ (1996) experiments would have been the same if they had used a questionnaire with non-metaphorical statements instead of using their metaphorical statements.

Discussion

Researching and writing this assignment has made me realise just how important analogies and metaphors can be in communication. I felt I had an understanding of the importance of them in the classroom before completing this assignment, as I was already using them to help students gain a better understanding on certain topics. I have now realised that I would usually only use analogies in my descriptions. By using analogies instead of metaphors, I was potentially missing a strong opportunity to encourage learning in my students. If I am to use a metaphor in place of an analogy in the future, the students will have to use their own imagination to interpret the similarity. This would not only give the student a greater conceptual understanding of the subject matter, but would help encourage the student to gain other skills, including resilience, communication, and lateral thinking. These skills have all been proven to enhance students’ understanding within the classroom (although this discussion is beyond the scope of this report). An example of a way that I plan to adapt my teaching will be while teaching electrical circuits, instead of telling the students reasons why an electric circuit can be considered to act like water in pipework, I could tell them that I want them to consider why this comparison exists, and discuss this with their partner in a “think, pair,

share". I could also try to use metaphors in an assessment for learning approach to gauge the confidence of the student's knowledge of a topic before moving on to new material. Additionally, I will apply metaphors as a referent for myself if the learning objectives contain different concepts, and require varied strategies.

Conclusion

Analogies and metaphors have a close link into human imagination and have been shown to help increase conceptual understanding of a topic, while also being powerful tools of communication. They are already well used in modern day science to help scientists create models and theories of phenomena that is currently not fully understood. Analogies and metaphors can be used in the classroom to help a student use previous learnt knowledge to better understand a topic that is new to them, which follows the constructivist approach to teaching. This is particularly helpful in science, where certain concepts can really push human imagination. Although there is a downside to using analogies and metaphors in the classroom, as some students may not fully understand the similarities between the source topic and the target topic, or they may take the metaphor/analogy too literally and fail to see where it may break down in the description. On occasions, metaphors/analogies may also create misconceptions in the students. To avoid this, it is important to be clear in your descriptions, when they are valid and when they break down. The use of analogies and metaphors have merit in pedagogy studies as well and they have been used to help both students and educators communicate their beliefs and understanding of the teaching and learning process.

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