Coursework wiki

Self Explanation and Catalytic Prompts

"Learning results from what the student does and thinks, and only from what the student does and thinks. The teacher can advance learning only by influencing what the student does to learn." *(Herbert A. Simon)*

Introduction

Determining the most effective way to learn is undoubtedly of key importance for those both teaching and receiving education. In order to not only remember information but to fully comprehend it, we must draw some conclusions about the most useful way to learn and understand information. What elements of education most successfully enhance learning?

While the input of expert knowledge from a tutor is arguably a key factor (VanLehn, 2011), educational research has indicated that the role of self-explanation may be of exceptional importance in the enhancement of deep understanding and learning. Self-explanation has been described as '…a mental dialogue that learners have when studying a worked example that helps them to understand the example and build a schema from it' (Clark et al, 2006). It is implied that those who take the time to work through information themselves process it more thoroughly. The use of self-explanation methods in eduction has been suggested to benefit both conceptual and procedural knowledge of individuals (McEldoon et al, 2013). Although the effectiveness of these methods has been investigated widely in educational research, a new branch of thought has been proposed that highlights the potential importance of catalytic prompts as a useful learning tool.

Whether these two methods are one and the same thing or whether they differ significantly in their approaches and effectiveness provides an interesting opportunity for debate. For a starter reference that clearly outlines the principle of 'self-explanation' see the suggested paper below: **Eliciting Self-Explanations Improves Understanding (http://chilab.asu.edu/papers/ChideLeeuwChiuLaVancher.pdf)**

The importance of Self-Explanation

To learn with understanding, Chi et al. (1989) note that students must draw conclusions and make inferences from the information with which they are presented, even when that information comes in the format of worked examples. Based upon this, authors content that students can be split into "good learners" and "poor learners", and although upon initial observation this seems to be a harsh distinction, the justification of such a distinction indicates the importance of learners autonomy and self- explanation and explorations of target learning.

"Good" students generate explanations for why certain steps must be taken, and rationalize these steps, which enables them to be adaptively employ similar, although not identical, strategies in problems which are slightly divergent from examples.

"Poor" students on the other hand, use examples as reference points, and refer to such examples as though they should be applicable to multiple problems, and to not identify them as specific solutions.

The difference between these two groups is that the "good" students provided self explanations in the form of inference rules. Such rules spell out more clearly the specific situations and conditions for particular actions, rather than a belief that generic principles can be applies across the board. Such inference rules need to be built up gradually to provide a reference network that can be applied across situations.

Interestingly, "good" learners spend more time on worked out examples than their "poor" peers. This enhanced "time on task" has therefore been attributed to the creation of a greater number of explanations, increased frequency of idea statements and enhanced number of statements that identify their own areas of understanding. It has therefore been suggested that examples should not be used for the provision of explanation, but rather should be used in the prompting of self- explanation (Aleven and Koedinger, 2002), which is a simplification of the notion provided by Catalytic Assessment.

What is Catalytic Assessment?

"assessment designed to lead to learning later, where that learning typically occurs without formative feedback but through processes internal to the learner" (Draper, 2009)

The purpose of Catalytic Assessment is quite simple - test questions are presented to students at a relatively early stage, the aim of which being to trigger a subsequent deeper level of learning, without direct "teaching" input. Paradoxically to how Multiple-Choice Questionnaires (MCQs) are often viewed (learning at it's lowest level, in the form of disconnected facts), Draper suggests that MCQs themselves are not an issue, but rather how they are used. When presented in an appropriate way, such questions can be used as a catalyst to prompt further learning in students, and therefore the immediate response of the student is in fact not diagnostic. Essentially proposing that how these questions are used is more fundamental that their format.

Draper provides an outline to do this effectively:

(a) Reason questions - presenting students with the answer, and making them select a rational behind it.

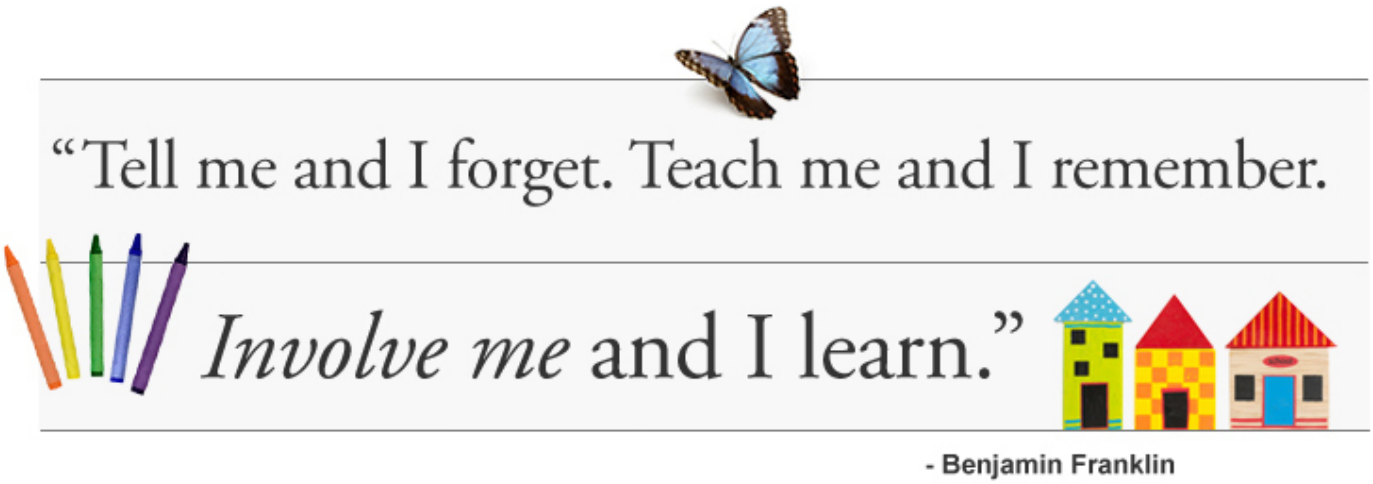
(b) Having learners generate reasons for and against each potential answer

(c) confidence-based marking: having students indicate their confidence in the accuracy of their response. With marks being given for being correct and for being confident. Preparing students for ways to decrease that uncertainty.

(d) Using brain teasers to prompt peer-discussion. Students are far more likely to create personal understandings an arguments when presented with information from peers, rather than from "trusted" or "superior" teachers.

(e) Getting learners to generate MCQs of which the best will be used in tests/exams.

How are such concepts currently applied in Educational Settings?



Actually, Franklin never said this.

Discovery Learning

In recent years, great emphasis has been put upon a method of teaching known as *"Discovery Learning".* Through this method students are still given guidance, however it is minimal. This method is believed to cause cognitive benefits, such as inquiry skills and learning from error. Termed by Mayer (2004) as ***"*guided discovery",** prompting students to take an active hand in their own learning has been suggested to cause more meaningful understandings, and due to it's self-generated nature, result in further transferability than simple rote learning. Many educational researchers believe that this then provides enhanced long term learning, in addition to more intrinsic motivation to learn from students.

Perhaps a good way to consider "*guided discovery"* might be in the layout of Honours Psychology courses. Students are provided with minimal lectures, which provide an outline of the topics. The expectation is for them to then research and discover their own findings and conclusions in these areas and present them at the exam.

However, as you might expect from your own experience of studying(!), discovery learning as been related to high levels of practice and longer periods of time spent on acquisition. Interestingly, without this time to consolidate their understanding, and without sufficient practice - the trial and error we might expect from Draper's forms of **Catalytic Assessment** - discovery students perform poorer than their counterparts (Brunstein et al., 2009). The relationship between this and revision periods for exams are then quite clear, as it provides students with time to consolidate their personal learning.

Interestingly however, an "Expertise Reversal Effect" has been found in relation to this learning method. Self-discovery has been indicated as beneficial for more experienced learners, and such individuals are thought to require lower levels of formal guidance. In contrast, more inexperienced learners have shown the opposite effect, and have been found to perform better with instructional guidance.

High Aptitude ⟶ Self - Directed Learning

Low Aptitude ⟶ Programmed Instruction

This effect suggests that type of instruction that is then implemented should be reflective on the progress of the learner. And this might be why methods such as Catalytic Assessment might not show the same promise with lower levels of education as they do in Higher Education settings, where by definition, learners have a history of effective learning.

Prompt Based Self-Explanation

While discovery learning requires students to research and draw their own conclusions with only very basic information provided to them, more directed forms of self-explanation are also used in practice. Hausmann et al (2009) suggest that different forms of self-explanation prompts can be used to promote learning in education.

Justification-based prompts
This type of self-explanation prompt draws from the work conducted by Chi (1989) on the use of self-explanation in education. It allows for individuals to bridge gaps in the deduction of conclusions which may not be clearly outlined. This technique is often used in educational practice, particularly in education institutions for younger years.. The purpose of this type of prompt is to encourage the individual to justify why they have made a conclusion or explain what rules led to their construction of an answer. By encouraging students to understand why they have solved a problem in a particular way, it may be argued that individuals learn from error because they can understand independently where they have taken an incorrect step.

One example in the literature of the application of justification-based learning is in a study of the effectiveness of self-explanation on the completion of mathematic problems by McEldoon et al (2013) 'Is self-explanation worth the time? A comparison to additional practice. The study asked students to solve simple mathematical tasks and then asked them questions about the problem they had completed (this is the prompt). Examples of the questions used were:

- 'How did you get your answer?'
- 'How do you think that a peer got an incorrect answer?'

This is one form of self-explanation prompt that may be used in education in order to potential promote more deep and thorough learning of material. However there are other forms of prompt that may also be applied to an educational setting.

Meta-cognitive prompts
Although justification-based prompts do not require knowledge of a topic, meta-cognitive prompts are focussed on the prior knowledge that a individual may possess. This type of prompt requires individuals to alter an incorrect schema in order to learn more comprehensively. Students who read information that does not align with the schema they possess about a particular topic are forced to create a self-explanation in order to alter the mental model they currently hold. Meta-cognitive prompts differ from justification prompts in that they relate to the prior knowledge the student has surrounding the subject e.g. 'How does it relate to what you have already seen?' (Hausmann et al, 2009).

How effective have such approaches been found to be?

The difficulties of using discovery-based learning

The literature surrounding the effectiveness of discovery based learning as an approach in education has failed to conclusively agree upon the success of this method. Recent research on this educational technique has implied that discovery learning does not stand alone as a useful method of deep and thorough understanding. Mayer (2004) provided a comprehensive review of the literature investigating the effect of discovery learning. The ideas expressed in this review provide the opportunity for the

effectiveness of discovery learning to come under scrutiny. Mayer suggested that due to the lack of structure associated with unassisted discovery learning students can not fully benefit from this approach, and as a result it may not improve student ability to understand the rules governing problem-solving (2004). This view is common throughout the literature surrounding the subject and the implication that some sort of guidance is necessary to promote optimum learning, is highlighted (Khlar, 2009). It is important to distinguish between guided discovery learning and unassisted discovery learning which may differ in their effectiveness. Without at least some form of initial guidance, it is argued that a great deal of valuable learning time is wasted by students while deciding upon a strategy, that could have been initiated by a teacher (Khlar, 2009).

While it is heavily implied that minimal input is necessary for successful discovery learning, it is still argued that the benefits of guided discovery do not outweigh the time and effort that is required by such a method. Alfieri et al (2011) investigated the benefits of carefully planned discovery learning which they termed 'enhanced discovery' in which learners are provided with minimal guidance. The results of this meta-analysis imply that learning can be optimized in older students when the right amount of guidance is provided. However, the paper highlights the difficulties in determining the right amount of input from teachers, and highlight the importance of scaffolding in providing the appropriate support. Although it is suggested that learners can improve when given the opportunity for self-explanation through discovery learning, future work must address how much guidance is required for optimum success in higher education environments.

The double-edged sword of self-explanation prompts

Self-explanation prompts are often used in educational settings as it is a technique that is relatively easy to employ. However there are discrepancies in the current research about how effective these prompts potentially are. By highlighting the evidence of three current papers, the benefits and limitations of this method become apparent.

McEldoon et al (2013)

- This paper looked at the effect of justification-based prompts on mathematical problems.
- Results found that those received prompts displayed improved conceptual knowledge than individuals who did not receive the prompts. Interestingly however, the effects were not significantly greater for those who received self-explanation prompts than those who were given additional practice.
- However, self-explanation prompts did appear to have a significant effect on the procedural knowledge of participants.
- The effects of the self-explanation prompts given in this study were far more modest than first predicted, suggesting that the benefits of the method in relation to the time required to execute must be carefully examined in future research.

Hsu & Tsai (2013)

- This study investigated the effects of using self-explanation prompts within an educational computer game. This technique used prompts that required participants to use self-explanations that related to their previous scientific knowledge.
- Contrary to previous findings and suggestions, the researchers found no significant difference in the scores on those who received prompts during the game, and those who played the base game.

It may be implied from recent findings that there may be both limitations and benefits of using self-

explanation prompts in educational settings. Berthold et al (2011) aims to explain why this may be the case. In this study university tax law students were given self-explanation prompts when asked to perform calculations. The findings of this experiment were exceptionally interesting and help explain why self-explanation prompts are not always particularly useful. The participants receiving prompts displayed an increase in the detail of their explanations and a rise in conceptual knowledge. However a reduction in the number of calculations that were made and the conceptual knowledge of participants, was reduced. Berthold et al (2011) suggests that self-explanation prompts can push the limits of knowledge processing in some areas, and as a result attention to other elements is lost and in turn deficits are evident.

Although it may be argued that there are potential cognitive gains of using self-explanation prompts, the issue of how much self-explanation should be used within education is once again highlighted.

Deep and Surface Learning

Learning is not a singular dimension, and therefore can be experienced in a variety of forms. A strong example of this is **"deep learning"** and in contrast, **"shallow learning".** These different kinds of learning differ in the way which a learner processes and conceptualizes the information. Educational specialists currently believe that the encouragement of deep learning will promote far better long term learning, and it is largely from a desire to promote such learning that methods such as **self- explanation** and *catalytic prompting* have emerged.

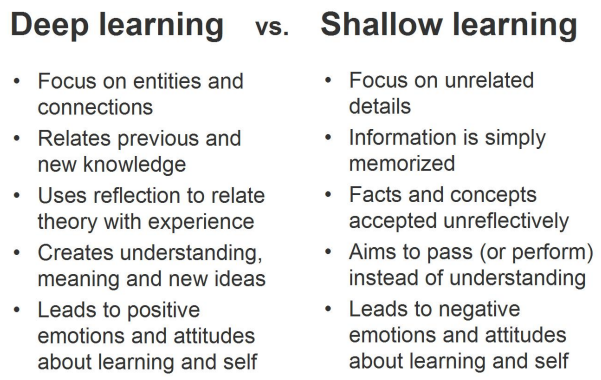
Deep learning

Deep learning, involves intention of understanding, engaging with, operating in and valuing the subject. Characteristic of students who take a deep approach is a motivation of interest. They actively seek to understand new material and relate ideas to previous knowledge, often using personal and self-referential examples.

Shallow (Surface) learning

The surface approach is often associated with students who seek to learn solely for the purpose of assessment. Unwittingly, the majority of students in formal education will gravitate towards this approach. The key motivation tends not to come from an intrinsic desire to learn, or a keen interest in the topic, but rather about completely the 'necessary'. Such learning can be associated with rote learning for exams. For example, a student may be able to list 20 references for an exam, but 6 months later would not be able to state which papers they had read. Motivations for shallow learning often arise through fear of failure, and some believe reflect and unsophisticated approach to their education.

A summary of the differences between Deep and Shallow learning can be seen below:



Relation between deep vs shallow learning and self- explanation

In order to determine a link between self-explanation and these two levels of learning it is useful to again address exactly what constitutes as 'self-explanation'. Roy & Chi (2005) describe this approach as follows: ‘Self-explanation is a domain general constructive activity that engages students in active learning and ensures that learners attended to the material in a meaningful way while effectively monitoring their evolving understanding. Several key cognitive mechanisms are involved in this process including generating inferences to fill in missing information, integrating information within the study materials, integrating new information with prior knowledge, and monitoring and repairing faulty knowledge’.

This is most comparable with the deep learning principle. If learners use their material in a meaningful way, it in turn will effectively increase understanding. As a result we may be able to draw a link between self explanation and deep learning. People who use this learning approach are also very likely to search for material and use it on a meaningful way by combining it with prior knowledge or creating inferences with the real world. If a person endeavors to achieve deep learning, it will be more likely that he or she will remember more as the information is likely to be understood rather than merely memorized. When people are able to learn deeply, it will help them to understand more fully and take time to examine the information. With shallow learning, they just try to remember it, without putting in effort to build a mental representation of the knowledge.

Effectiveness

In 1970, Perry (1970) found that students learned in two ways. They differentiated between a reproduction of knowledge based on memorization and a transformation of knowledge based on meaning. In 1976 Marton and Saljo identified the concept of deep versus surface learning. They also found that some students learned using a surface approach only, and others on the deep approach. In their research they found that students who used the deep approach, had a better understanding of the material and the related questions. These students remembered more messages effectively and had higher quality learning outcomes then the other students who used the surface approach.

Overson and Venassi (n.d.), also conducted research on this topic.. This research involved fifty- four students in an introductory statistics course. They completed the first in- class exam and looked at the difference in learning approaches (deep and shallow). The conclusion of the research was that students who reported higher use of deep processing while preparing for the exam, performed better than students who reported lower levels or deep processing. Students who reported high use of deep processing and low use of shallow processing, performed especially well. In contrast with this they found that students who reported low use of deep processing and high use of shallow processing, performed especially poorly. Further studies have aimed to replicate this, and in turn have discovered similar results. A potential limitation of the research discussed is that it is not experimental, people were simply asked how they believed they had learned the material, so the implications of these results can not be generalized to all students. However further research has aimed to demonstrate the strength and effectiveness of deep learning. Throughout higher education and universities, the goal is to achieve deep learning processes.

Practical advice

In the research conducted by Meek, Williams, Knotts and James (2013) the learning preferences o three generations was examined. It was concluded that older generations had the tendency to prefer deep learning, while younger generations will more often rely on the surface approach of learning.

One's choice of the learning method is also related to the structure of the required examination. If teachers ask questions that can be answered with only minimal details stored in short- term memory, there is a high probability that students will not use the deep learning approach. Most teachers recognize that their test format will directly influence student's choice of study strategies (Weimer, 2012). This is an important matter to address, if we want to stimulate the more deep learning and comprehensive understanding in students.

Strategic learning

Lublin (2003) also discussed the *strategic learning* approach, which is closely tied to both deep and surface learning. The central aim of this approach is to facilitate a desire for positive learning outcomes within students.

This can be characterized by:

• Intention to obtain high grades

• Organization of time and distribution of effort accordingly

• Ensure that the conditions and materials for studying are appropriate

• the use of previous exam papers to predict questions

• being alert to cues about marking schemes

However, it is important to note that, although learners can be classified as deep or surface learners, the learning styles are not mutually exclusive. This means that a person can use both approaches at different times (Arherton, 2013).

The website from EXCHANGE.AC.UK (n.d.) gives a very nice overview from the deep and surface learning approaches (http://exchange.ac.uk/learning-and-teaching-theory-guide/deep-and-surface-approaches-learning.html) with the definition, characterised, students and teachers approaches.

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