The Role of Motivation in Supporting Preparation for Future Learning and Knowledge Transfer

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Relevant article D. M. Belenky and T. J. Nokes-Malach, Motivation and Transfer: The Role of Mastery-Approach Goals in Preparation for Future Learning, The Journal of the Learning Sciences **21**, 399-432 (2012).

Transfer: “classic” definition is the ability to use prior knowledge and experience to solve novel problems.

Examples:

- Writing an email from a mobile device for the first time – you have to use prior knowledge about writing emails on a desktop device.
- Learning discipline (e.g., physics) concepts in a particular context (e.g., a problem) and using them to solve a different problem which uses the same concepts.
  - This is typically one of the goals of instructors (whether college or K-12).

For example, in learning how to solve a problem, students can acquire different kinds of knowledge: concepts, equations, solution procedures, and can transfer any or all these to a new problem with slightly different features (what is commonly referred to as “near” transfer).

Understanding how transfer happens is critical for education because designing instruction in a way which facilitates transfer of knowledge from one context to a novel context is often one important goal of education.

- A lot of prior studies have investigated transfer (see references towards the end of the presentation), both in a lab setting (i.e., out-of-class research study) and a classroom setting
  - Sometimes evidence of positive transfer has been found
  - Other times, failure of a learning task to promote transfer has been found, even in situations in which the near transfer was investigated (e.g., very similar contexts for a problem in which learning is embedded and the transfer problem)

Dimensions of transfer:

- Researchers have developed a taxonomy of transfer which has different dimensions
- One dimension very important for education is the temporal one, and we are typically concerned with intermediate transfer, i.e., being able to use knowledge acquired several weeks later in appropriate contexts.
- Another important dimension is the content dimension:

- Near transfer: execute the same procedures, for example, learning certain procedures to solve a problem, and repeating those procedures in a very similar problem (e.g., everything is the same, except numbers are changed).
- Intermediate transfer: adapt the procedures: for example, learning certain procedures to go from some initial conditions to a final goal, and adapting the procedures to go from different initial conditions to a different goal (e.g., learning problem: x,y,z given, students asked for some quantity A, transfer problem, x,y,A, given, students asked for z)
- Far transfer: learn the concepts involved in the learning task and transfer them to situation with different surface features (e.g., learn how use conservation of energy to solve a problem with a block sliding on an incline plane, and use conservation of energy in a problem involving a boy on a swing).

Researchers have found that focusing on learning procedures from problem solving typically shows very low transfer on problems in which the context is very different (i.e., not focusing on concepts involved in solving a problem and just learning the steps required to solve it, makes if very difficult to transfer to a new situations which does not have the same exact surface features).

An example of far transfer is learning statistics concept in a statistics course, and after the course is over, students in that course are given a survey (unrelated to the course), which has some statistics questions embedded in it.

Bransford and Schwartz have developed a new framework which describes transfer as preparation for future learning. They designed certain tasks to better prepare students to learn from a new resource. Again, this is very much in line with the goals of education – we want students to be able to use resources provided to them outside of class (e.g., homework) to learn the concepts we are covering in class, and not just focus on learning procedures.

- They designed “invention tasks” (structured inquiry tasks), which ask students to come up with procedures to solve very novel problems **before** being presented with effective procedures (examples to follow). Students invariably struggle to come up with the procedures themselves, but when instructed with the effective procedures, they learn a lot more.

Research done by Dr. Nokes-Malach:

Students instructed in two different ways:

1. Tell-and-practice instruction: given a procedure to solve a particular problem and then provided with opportunities to practice the procedure (similar to ‘traditional’ instruction) – in this study, students learned about mean and mean deviation
2. Structured inquiry: given a data first → task: come up with a mathematical procedure to determine which pitching machine is the most reliably

    - The data was carefully crafted to get students to think about certain distinctions between different data sets which are related to the concepts they learn.
    - Important to note that students mostly fail at this task (it is difficult!), which is why it is important to provide some direct instruction afterwards (e.g., lecture, worked example).

In a prior study, researchers found that using invention tasks helps students learn significantly more from worked examples than students in a tell-and-practice condition (in fact, in the tell-and-practice condition, students did not gain anything from the worked example – whether it was used or not, performance on a transfer task was similar).

Several questions related to using inquiry tasks were discussed:

- Suppose you use inquiry tasks on a regular basis. In general, students struggle with determining the appropriate procedures/concepts. After they struggle, lecture-like instruction is used about the procedures/concepts. So if students see repeatedly that they are asked to complete invention tasks, but then the 'answer' is provided to them, would their motivation to engage decrease over time?
    - Research was in general carried out with only one or several invention tasks in either an in-class study or a laboratory study, it is unclear whether such an effect would occur.
    - It would also be important to frame to the students the importance of struggling. Perhaps discussing the research results showing that struggling before learning the 'correct' procedures or concepts leads to improved knowledge transfer can motivate students to continue.
        - Also, invention tasks are interesting are related to real-world applications, which can also motivate students to engage, especially when working in groups (which is a typical recommendation)
- How can you identify good vs. bad invention tasks? For example, in the research discussed by Dr. Nokes-Malach, the invention task was two dimensional (determine which pitching machine is more accurate from a 2D plot), but instruction was 1D. Is there a general rule that the invention task be more challenging than the instruction task?
    - The main criteria is that the task should provide opportunities for students to discover the features that you want them to. For example, in the pitching machine example, all grids had the same number of observations except for one, which had more. This prompts students to think about how to incorporate the number of measurements in a mathematical procedure – a feature you would want students to think about.
- Are there certain concepts/procedures for which invention tasks are more or less suited?
    - It certainly depends on the context – for certain contexts it will fail
    - However, invention tasks have been found to be useful for teaching certain things that one may not expect, for example, certain grammar rules for students who are learning English as a second language.
- Can invention tasks just be used to frame the introduction of a certain procedure/concept?

- Sure, they can be used for this purpose, but one should not expect similar results in terms of student learning as using invention tasks to get students to struggle first.
- There is a lot of educational literature which shows that struggling is a stepping stone to learning, and removing the opportunity for students to struggle to figure out a procedure/concept can greatly reduce how much they learn.

Invention tasks have features related to promoting mastery goals (i.e., interested in learning the concepts and not just procedures to solve problems):

- Students are given authority and control in working on a challenging task

One question naturally arises: would use of structured inquiry tasks increase the percentage of students who adopt mastery goals? The research Dr. Nokes-Malach did suggests that it can.

Achievement goals have been described by Elliot on two dimensions (mastery vs. performance and approach vs. avoidance) which leads to four possibilities:

- Mastery-approach – "I want to understand the concepts in this course"
- Mastery-avoidance – typically common in people who have learned something already – "I don't want to forget what I already know"
- Performance-approach – "I want to do better than other students"
- Performance-avoidance – "I don't want to do worse than most students"

Mastery-approach goals have generally been found to correlate a number of positive learning outcomes (e.g., improved performance, better attitudes, better learning experiences, persistence in the face of challenges, help-seeking behavior etc.)

Performance-avoidance goals have uniformly been found to correlate with many negative learning outcomes (decreased performance, negative learning experiences, self-defeating behavior, help-avoiding behavior etc.)

If invention tasks can improve student learning goals to be more aligned with mastery-approach goals, this can help with their motivation to learn and improve learning outcomes. Dr. Nokes-Malach found that students who engaged in the structured inquiry learning activities improved their learning goals. This was after only one such activity in a lab setting (i.e., participating in research). It is possible that multiple use of structured inquiry activities leads to multiple improvements in adoption of master-approach learning goals – which can lead to improved transfer of learning.

- In this study, they found that mastery-approach goals were strongly correlated with probability of transfer.

Another interesting finding is that students who were high on the mastery-approach orientation performed well on the transfer task regardless of learning condition (invention task, tell-and-practice), but students who were low (initially) on the mastery-approach orientation performed better in the invention learning condition.

- This is an indication that "good students" can learn even with traditional instruction, but low-achieving students benefit from structured inquiry tasks.
- It is possible that structured inquiry tasks have an effect of motivating students to learn – will be explored in future research

A few minutes were spent to discuss a similar research study:

- In an introductory course, students had access to lecture slides before coming to class
- The lecture slides contained most of the material covered in that class, but there were quite a few gaps which students would fill out in class
- If a student downloads and prints the lecture slides before coming to class, this can be an indication of a student who has mastery-approach learning goals
- They found that downloading of the lecture slides was strongly predictive of grade in the course.

In the final several slides, Dr. Nokes-Malach provides references for those interested in learning more about research on transfer.

(See the invention task website at Rutgers University for more invention tasks that can be used in physics)