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Original Paper

The Competition between Productive Failure and Direct Instruction Is not Determinable: A Review of the Deviations and Reasons

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Abstract

Teaching the learner new information demands careful implementation. The implementational protocols are derived from instructional ideologies and purpose of the design. It not only requires the instructors to grasp the essence of instructional designs without an extemporaneous amending or exchanging of the theoretically proven meaningful teaching events, but also, a precise actualization of structure and approach as well as its behind ideology is demanded. Those rationales and references for instructors to determine when and how to implement instruction, what practice or what strategies are needed to be taught ought to be precise enough to separately explain their advantages and prediction of outcomes in learning. In this article, we explored how both problem-proceeding learning and guidance-proceeding learning are beyond control regarding the deviated cognitive processing those instructional procedures can possibly elicited.

Keywords

Instructional variables, Instructional design, Learning effect, Individual factors, Instructional deviation

1. Introduction

An obstacle for contemporary studies to determine the effectiveness of any instructional design would require careful examination of effects from a range of attributes. These include the type of learning events, the domain-specific structure of knowledge, and each learner's individually based variables (Lodge et al., 2018). Some of them have resulted from the sets of provisional experimental specifications, in other words, possible differences between specific goals of different activities involved in learning. In this article, we reviewed the designs of 'Direct Instruction' and 'Productive Failure', to see how a slight change in instructional events would evoke a change in learners' attitudes, behavior, and cognitions when they are being instructed following these two designs. Note that the change may not only come from the instructor's end but also from the learner's individual variance. Such as prior knowledge content can dynamically interact with instructional protocol or unevenly introduced concepts may each interact with learners' own personal interests and relevance to be detected.

2. Framework: Where Does either or not Restricting the Direction of Learning Nudge Learners to?

Whether to restrict the direction of inventive productions has long been an issue in instruction, one side said that introducing some disciplinary norms and expectations is helpful in problem-state exploration (Kapur & Bielaczyc, 2012), the direction of learners' generation by the learner themselves is too random and uncertain (Metz, 2004). However, the other perspective holds that the company of a tutor makes learners too dependent on the help (Brunstein et al., 2009), learners need to rely more on their own inventiveness, unregulated they would generate a selection of procedures that are differently motivated than in pursuit of a good performance (Hiebert & Wearne, 1996). A complex involvement of self-efficacy and the wish to be flawless costs the openness of mind, by themselves they may try to avoid any optional solutions in which they are not quite confident, even if taking the plunge would produce a better outcome for them.

We first hold the ground for the latter perspective, they state that learning with active generation typically provides beneficial effects on learning (Bertsch et al., 2007). A deviated conceptual structure derived from failed exploration can still stumble onto the correct answer (Schwartz et al., 2005). Via a seemingly random stroll through the procedures, learners can still find solutions and remember the process of how they find them (Brunstein et al., 2009). Relevance still presents for the seemingly random learner-generated procedure, A derived experience from irrelevant production can still be potentially relevant (Öhman, 1992).

That has inferred the accessibility of knowledge. Through explorational experiences, learners cannot only acquire concepts or procedures but also potentially have access to the strategy that supports them. Strategy can be explicitly taught or discovered just as solid concepts do, depending on how this particular type of information is conveyed. The relationship between strategy acquiring and concept acquiring is a trade-off, giving explicit interpretations restricted shortens the process of accessing the knowledge. Inventive production allows learners to innovate a deviated solution and keeps it 'indistinctly moving along the correct direction'.

To ask for the learner to generate also elicits the need for relevancy connection, thus enhancing the ability to incorporate domains as well, the learner infer concepts from other domains. When the guidance was withdrawn, students were found to be more capable of seeking similarity or general linkage (Brunstein et al., 2009). Learners may gather learned clues or switch onward superordinate knowledge dimension and thus link back and forth. It is noteworthy that for this connect ability to function, it would first demand the knowledge base to be solid and vivid.

The deficits of minimal guidance instruction are caused by its practical deviation from the original designation. Exploration can be too frustrating not knowing whether are ever heading to the right, therefore practice often invokes a gradually allocated scope of exploration (Loibl & Rummel, 2014a). This variant rule shrinks the desired problem space in the original open exploration (Hmelo-Silver et al., 2007; Quintana et al., 2004). Or it causes learners to cut through inquiries that were designed because there is no pipeline to follow, learners would have the freedom to skip the further inquiry, but jump to conclusions (Kapur, 2016; Soderstrom & Bjork, 2015). On the other hand, direct instruction provides a pathway of thinking that cannot be bypassed. The third deficit is when instructors restrict the problem too much, only presenting a very slight knowledge gap, and then learners limit their own scope (Schwartz et al., 2012). For inventive production, inquiries must be carefully designed to elicit the learner's initiative in the expansion of problem space, a limited inquiry demand would lead to a limited search.

So far what we were trying to elaborate on is how not giving instruction could have a deviated result than a pure exploration. Then we discuss whether instruction could press what ought to be learned to learners. Instructors mistakenly took the impression that they ought to withhold the information until learners can develop on their own, but the reality is that the instructor has an obligation to regulate the presence of information and tasks. But when detailed guidance was reviewed, it involved more variates regarding what kind of and how much regulations can be placed given the variety of guiding content and to varying degrees of its influence.

The task of memorizing the solution and concepts shredded too much light upon the 'waypoints', but not for information that further intergrading the waypoints, particularly when a subsequent evaluation also emphasizes that waypoint information and disregards ecological application scenarios or intuitive understanding. A learner may hence forget the original fluent version of the solution and miss their role to improvise or the role to draw inferences based on the true expectations of their performance. An overemphasis would also lead to unawareness of the inconsistency between the solution-generating context and the context when it comes to future applications (Schwartz et al., 2012).

3. Students: What Is Learned Relies on How Learners Believe they Shall Perceive

Learner differences are derived from a spectrum of different levels of prior knowledge (Loibl et al., 2017), and the response to scaffolding interactively is critical.

Some learners are more endurable for prolonged tests and exploration, yet others might easily feel frustrated. Deciding to endure the confusion and search for a self-regulatory learning strategy relies heavily on learners' prior knowledge (Wood et al., 1976). Another motivational aspect also matters, that is the "willingness to endure a condition of mental unrest and disturbance (Dewey, 1910, pp. 13)", learners would involve themselves in deeper thinking to achieve an outcome. Self-concept is also an important factor in determining the effectiveness of instruction (Richter et al., 2022), and knowledge about self-deficit is the key to influencing learning.

Individually learners would vary in their ‘dedication’ while facing a problem, by expressing various levels of self-efficacy, learners would each generate levels of confidence for the problems (e.g., Butler et al., 2008). The quality of exploration can range from a gingering guess-and-tryout (those who have been expecting errors to happen at any minute) to arbitrarily put into implementation (those who hardly foresee the error is upcoming). The ‘dedication’ can lead to various selections of approaches, whether to brainstorm, seek feedback, or mimic works from others. And this is determined by how they believe in themselves for already being pursued through the right way. In reverse, dedication depends on each learner’s own knowledge about when and how could they be actually wrong, or their self-criticism, when getting a solution learners will tend to believe they have learned and know the target content, even though at the time they have not yet acquired the knowledge (Metcalfe, 1998).

Too much confidence can also deviate their learning by causing them to decline further study, or change their area of focus (Finn, 2008; Metcalfe, & Finn, 2008), over-confident learners tend to stop considering other solutions (Ackerman & Thompson, 2017). van Gog and colleagues (2011) contrasted the dynamic of awareness for the learner, without recognizing their deficit in generated solutions, learners would have a strong faith in their own generation, they can face the problem again and thus show reluctance to think further. Residual untested knowledge/solution will then become an inevitable error while reencountering the problem. Thus, having learners think of their own possible errors can be inspirational especially in anonymity (Schiff et al., 2009).

4. Contents: Where the Design has been Deviated from Simple to Directive

Though the core workflow is highly condensed for classes and ecological experimental conditions using the same design, in an angle of more detailed implementation, when and how any micro-events are delivered would potentially deviate the progress.

Whether or not explicitly encouraging learners to generate alternative solutions has a tremendous influence on learning patterns (Carpenter et al., 1998). Instructors may deliberately design the inquiry problem, to restrain learners’ attention towards specific contrasts (Loibl & Rummel, 2014a; 2014b), instead of giving them a rich problem close to real-life complex scenarios. It is applicable for instructors to further guide the direction of their exploration, for example, ask them to make predictions (Holmes et al., 2014), or factitiously intervene in their attention onward certain factors (Roll et al., 2012), or present small-step problem states in response to a bigger problem (Loibl & Rummel, 2013). Also sometimes instructor does not “broadcast” the canonical solutions but makes pairwise comparisons from learners’ solutions (Kapur, 2012; Loibl & Rummel, 2014b). Rectification of the students’ incorrect misconceptions rather than specifying the standard concept (Booth et al., 2013) is applicable, but experimentally they may trigger different interactions with the design. Bonawitz and colleagues (2011) noted that this instructive intervention during problem-solving led learners to withdraw from an exploration of the secondary implication or goal while searching for the resolutions. One another deviating implementation involves immersing learners into a variety of worked examples, by repetitively encountering one type of problem, they are expected to learn differentiation, categorizing, and recognizing the deep features (Paas & van Merrienboër, 1994), note that approaches evoke memorizing deep feature may not elicit memorization of the concepts and procedures themselves. And "examples", some implementation involves studying examples that have been worked out rather than trying to solve the problem on their own (Cooper & Sweller, 1987; Sweller & Cooper, 1985), even an erroneous example (Adams et al., 2013). By reasoning that it elicits more advanced retention and transfer by an active reconsideration and reasoning of substitute solution. So, giving the worked example or not is suggesting differentiated pieces of information conveyed.

Timing, in general, is one of the variables when giving any instruction. For example, a timely imbalance would affect learning even if the messages conveyed are the same. Not to mention that in the contradiction of those instructional designs such as 'Direct Instruction' and 'Productive Failure', the presence of either guidance or inquiry is at different time points. Meanwhile, in specific instructional cases, latency between the illustration and problem, or the worked example and problem, can easily interfere with the thinking, example substitution, as well as the self-reevaluation afterward.

5. Practice: How the Need for Repetitive Trials or Rehearsal Is Manifested

The construction of instructional designs also involves the instructor's insertion of practicing and rehearsal, or the design of 'Productive failure' itself is already addressing reliving the inquiry phase when being actually indoctrinated. Practicing or rehearsal enhances automatic re-actualization for previously constructed stimulus-response pair, creating an intense mapping of the S-R association that adds the speed or likelihood of automatic translation (MacLeod & Dunbar, 1988) when it must be triggered again during the interpretation of knowledge from another domain. Therefore, practice alters the reactivation of prior knowledge or changes the resilience of previously generated dysfunctional procedures. Repeated instruction is sometimes can be more beneficial (Rittle-Johnson et al., 2016). Frequent presentations of stimuli are thought to improve behaviors (Moors, 2016), the repetition enhances expertise and utilization (Kiesel et al., 2009). Yet while the repetition, the learning does not occur in a continuous accumulation (Musfeld et al. 2023). Practice also serves as an inquiry function, so that learners are not merely passively re-intaking the knowledge again but consider its meaning and use.

"If you read a piece of text through twenty times, you will not learn it by heart so easily as if you read it ten times while attempting to recite from time to time and consulting the text when your memory fails. Bacon (1620/2000, as cited in Roediger & Karpicke, 2006b, pp. 181)".

The indulgent exploration alone didn't create enough opportunity to examine learners' acquiring of the knowledge. Hence practice and problem-solving are very much alike (Collins et al., 1989), both these testing activities support the retention of knowledge as well as alter it into a more applicable form

(Roediger & Karpicke, 2006a), they resemble in the way that they both introduces an inquiry of the application of the knowledge within an adequate relevant difficulty which means learner have sufficient knowledge to at least access to the problem-space, and they both have a goal to enrich learners' means of resolutions so that learners will eventually be able to do what master and expert does every day (Lave et al., 1989). It was the reduplicated practice of inquiry and retrieving that enhanced the long-term retention of knowledge (Karpicke & Roediger, 2007; Roediger & Karpicke, 2006a; 2006b). The process of 'practicing' is rather a deliberated designed applicational review of concepts and procedures, instead of a simple insertion of replicative activities, and subsequently assuming that learning will incidentally add up (Prawat, 1995). So the effect of an inquiry or practice would depend on the instructor's desire to implement either a surfaced inquiry or something that elicits deep thinking.

Intuitive concepts are very resilient to change (Duit & Treagust, 2012), some would argue it would need as much as 96 times practice to intrude on the original belief (Dunbar et al., 2007). A simple wrong intuitive reaction tendency would require as much as 80 trials to wear off (Hommel, 1996). Therefore, the concern is about how repetitive practicing can eliminate the naïve belief, even a slight deviation among repetitive trials could render the learner unable to be aware of the previous memory trace as well as inaccessible to the previous encounters (Musfeld et al., 2023), so the concern covers for, while being instructed, how long the intruding knowledge may wear off even instructor repeat the knowledge again and again, and there is this concern for problem-led learning that whether it is good to firstly introduce a wrongful knowledge. Learners "reconsolidate" when encountering "abnormal contradiction" (Dunbar et al., 2007) but do not completely overwrite the previous intuitive error.

6. Feedback: It led to Learning via the Route of Reasoning

Feedback provides critical information to teachers and learners (Butler & Roediger, 2008; Dunn & Mulvenon, 2009), mistakes and feedback are crucial for learning (Kornell & Metcalfe, 2014). The feedback helps in focusing on what needs to be clarified. Goal-directed learning behaviors depend on the awarding or punishing characteristics during the learning (Thorndike, 1911; Colwill & Rescorla, 1986). Asking learners to interpret and explain their errors is helpful for them to form conceptual change (Siegler, 2002).

Instructors may use various techniques such as asking and answering by themselves, exclusively warning of a possible error, or the negative example for learners to mentally simulate and analyze, as well as interrupting learner's deviated consolidation by simply repeating the rightful concept or procedure again, to mimic a problem-feedback pair during self-monitoring and self-correction. The privilege of feedback is from the correct answer of feedback rather than a simple indication of correct or incorrect (Finn & Metcalfe, 2010).

Learning from the feedback to an error relies upon self-explanation. While learners get to correct their answers, they might at the same time reform a new rationale and justification for the methods and strategies brought by the new approach (Dewey, 1910). Siegler (2002) pointed out that the advanced learning effect is because learner thereafter put their attention onwards correct reasoning and perform an in-depth analyzation. Meanwhile, If the feedback is to further encourage a free exploration of the “midcourse process” in finding different ways to reason and to reach a solution, then the advantage of it may also extend (Finn & Metcalfe, 2010).

The timing for giving feedback can trigger a differential learning effect (Kulik & Kulik, 1988), delayed feedback has contributed to better learning than instant feedback. Changing the interval between assessment and feedback creates even more variates. Learners themselves, if given the vacancy, there is a chance they would review the applicability of their solutions and, therefore self-generate feedback (Roll et al., 2014).

Learners would be more likely to notice the deep features of the problems if feedback or subsequent instruction were based on learners’ own solutions (Loibl & Rummel, 2014a). There could be a gap between performance evaluation and actual ability which is termed “calibration bias”, typically for the case of an “invention”, learner-generated solutions are potentially not thought of by the instructor, they may not be representative of the learner’s capability as well as the coping to the problem space, the problem itself in that sense is deviated, that means the presented feedback is not always rightfully in responded to learner’s need. If while in the implementation the feedback is too frequently given, it not only interferes with serial thinking but also causes difficulty in the integration of knowledge. Learners’ belief in ever finding the rightful solution also matters (Hiebert & Wearne, 1996), living in a situation where they believe they are being monitored, given feedback, or stimulated would provide extra confidence for them to believe they would eventually get the rightful answer, rather than not knowing in advance whether their exploration is being examined.

Another factor that determines the efficiency of feedback is ‘the agency of the error’. Which states the benefit of feedback could also be attributed to observing the performance result from a third party. Kapur (2014) argues the effect of seeing others make an error is about the same as making a mistake on their own. Kornell and Metcalfe (2006) argue that feedback on one’s own performance is more helpful for the retrieval of correct answers, and observation of feedback intervenes in the processing sequence. A consolidation period is required to interpret the observed feedback, yet observation often cannot guarantee such a pause to think.

7. Failure: Being Treated Differently from Case to Case

The variants that a failure-drive instruction can elicit are not limited to its impact, but very fundamentally how such an approach alters the way of learning. The major issue defining the effect of a failure/error-driven instruction would be the error’s characteristics.

The type of error a learner has encountered can be influential in learning outcomes. A foreseeable error or an inconvincible error invokes a different encoding strategy (e.g, Petscher et al., 2009) or differentiated consolidation (e.g., “hyper-correction effect”, Butterfield & Metcalfe, 2001). In the meantime, each error has its own extent of malleability. Such malleability of error interacted with the individual factor and caused different performances among high-confidence errors and low-confidence errors (Metcalfe & Huelser, 2020).

Individually, learner's motivational attribute, self-esteem, and goal orientation shape their attitude toward failure. If learners believed in their incorrect answer, it has been shown to cause a difference in attentional engagement (Butterfield & Metcalfe, 2006). Studies (Butterfield & Mangels, 2003; Metcalfe et al., 2015) found the brain potential component P3a representative of the surprise response as well as an inner rating of confidence, and the functions thereafter, which would rally attention (Friedman et al., 2001) and enhance memory (Paller et al., 1985). Metcalfe and colleagues (2012) have associated this process with a medial frontal area inside our brain, typically the anterior cingulate. Hence if participants are more vulnerable to the surprise caused by high confidence yet surprisingly fail, then we could anticipate an enhanced attention and memory would be induced.

8. Conclusion

By reviewing many aspects of instructional design, we would be able to conclude that ecological experimental studies implementing instructional designs are not likely to come to the actual result of whether a guidance-led instruction or a problem-led instruction is better than the other. There are simply too many variates that interactively affect the final outcome of learning, those factors may be due to a personal aspect, an implementational deviation, or sometimes it is just about timing which changes much of the result. In summary, we appeal to find the domain-general optimal pedagogical designs that could only be through more basic studies concerning cognition and neurobiology.

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