On the Linearity of Gagné's Learning Hierarchies

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Introduction

Task analysis is an extremely helpful step in creating instruction. It allows to identify crucial topics of content that will help learners successfully reach the goals and objectives of a course. In their book on task analysis tools, Jonassen, Tessmer, & Hannum (1999) write, "Like an architect, the instructional designer use task analysis as a framework for building an instructional lesson or a learning environment" (p. vii). The metaphor of an architect is useful, as far as planning is concerned: a good architect starts construction only after s/he designs a detailed and mathematically accurate plan of a would-be building. Likewise, instructional designers develop instruction only after they create a detailed blueprint of what it will eventually look like.

While task analysis does not guarantee perfect instruction, it precludes gaps in the flow of instructional materials, whereby keeping the flaws in the learning experience to a minimum. One such tool is a learning hierarchies analysis (LHA) which was developed in the 1960s by a prominent instructional designer and educational psychologist Robert Mills Gagné. In his seminal paper "The Acquisition of Knowledge" (1962), he proposes that a certain bulk of knowledge can be broken down into smaller pieces—from simple to more complex. He concludes that simple pieces of knowledge are subordinate to more complex ones and serve as building blocks to the superordinate knowledge (Gagné, 1962). In other words, to be able to learn more complex knowledge, one should learn the necessary prerequisites first. To give an example, if one needs to learn to add numbers, one should first learn the idea of numbers.

Yet this approach seems to me somewhat reductionist and schematic. It implies that we only learn something complex only when we purposefully learned the prerequisites, which a lot of times is not the case, as indicated by the criticism of this approach in the scholarship. In this paper, I want to explore the advantages and disadvantages of this method and determine whether LHA should be widely used in creating instruction. I argue that it shouldn't be used for the purposes of creating instruction because of its limited and linear approach to the phenomenon of knowledge acquisition.

Following the introduction, I review some literature on the topic of LHA and describe this task analysis tool. Then I provide a case study which employed this method and discuss the advantages and disadvantages of the method. The paper ends with a conclusion and a reference list.

Literature overview on leaning hierarchies analysis (LHA)

For this paper, I chose six sources that talk about Gagné's learning hierarchies. I should point out in the beginning that there is no significant contemporary literature on the learning hierarchy model, all sources but one are at least 35 years old. I consider this a limitation, yet it may indicate the time where this task analysis tool was in its heyday—between the 1960s and the beginning of the 1980s.

In the above-mentioned article "The Acquisition of Knowledge" (1962) where he laid the foundations of the learning hierarchies approach, Gagné proposes that learning is a cumulative effect of each piece of instruction in a sequence. Gagné suggests that a learner should first master easier pieces of knowledge before more complicated ones. That is, learning basic facts should precede learning rules and concepts as well as solving problems. His research was initially focused on hard sciences such as maths and physics, which provided him enough evidence of the fact that knowledge has a hierarchical structure. Hence, Gagné states, learning sets in a particular content should be created and sequenced from basic to complex during instruction. In other words, he asserts that for better instruction (and prior to it) LHA should be conducted (Gagné, 1962).

White & Gagné (1978) conducted an experiment in a secondary education setting and conducted a posttest on a topic without prior teaching, revealing that "students frequently recalled higher elements while being unable to recall lower ones" (p. 93). They suggested that there could have been a downside in the instruction, and the order of instructional materials should have been reconsidered. The study indicates that not only learning is hierarchical, but also remembering is hierarchal (93). In other words, Gagné in a way confirmed the correctness of his LHA model. Dick (1980) used the same case study and showed how formative evaluation can be made quickly and economically by simply looking at the percentage of students who demonstrated learning of a particular set of skills. Dick's study corroborated Gagne's LHA model.

Other studies used for this papers are more critical of Gagné's model. White (1973) states that this model was "of great attraction and use to teachers and curriculum developers" (p. 374), but at the same times critiques it for its straightforward linearity. Bergan (1980) also identifies where LHA worked well: (1) it demonstrated Piaget's findings, (2) it justified the use of diagnostic testing, (3) it sequenced chunks of materials in designing curriculum. However, he points out that LHA fails to explain such well-known phenomena as transfer of knowledge and environmental together with individual factors that influence learning (Bergan, 1980, p. 625).

Bergan & Jeska (1980) both criticize Gagné's model and propose an alternative structural approach to understanding knowledge acquisition. The main difference between the learning hierarchy model and structural model is that the former is quite linear while the latter is somewhat three-dimensional and reminds a complicated spider web.

Overall, the review of the literature suggests that Gagné's model spurred some debate at the end of the 1970s and the beginning of the 1980s, with obvious positive aspects indicated and obvious drawbacks critiqued.

How does LHA work?

LHA is a technique for designing instruction by means of classifying knowledge that has to be learned into subordinate (prerequisite) and superordinate set of skills, putting them in a hierarchical order, and sequencing instruction in a way that allows students to master subordinate skills before they master superordinate ones. The purpose of LHA is to create a structured and dependent break-down of skills that are necessary in order to achieve certain learning outcomes by the end of a course in a logical manner. LHA covers only the content that will speak to the objectives of a course.

According to Bergan (1980), LHA is based upon two assumptions: (1) there are subordinate skills which precede superordinate skills in learners (prerequisite skills), (2) prerequisite skills facilitate the learning of superordinate skills (positive transfer) (p. 626). LHA asserts that in order to perform a complex task, a learner has to know how to do smaller subtasks that underlie it. For example, in order to add fractions, one needs to know what a fraction is, the rules of how to add them together, and the nature of adding. Not only does the task have subtasks but these subtasks are in a hierarchical relationship with each other. First, you learn what adding is, second, you learn what a fraction is, third, you learn how to add fractions. In an ideal world, the number of subordinate elements should be as exhaustive as possible. It is done in order to create the instruction which will best teach the learner to perform a complex task.

The question is: how to create the hierarchy of skills necessary to perform a complex task? To do it, one should pose a profound question and answer it—the same question posed by Gagné (1962): "What kind of capability would an individual have to possess if he were to perform this task successfully, were we to give him only instructions?" (p. 356). If an instructional designer

keeps breaking down the task into smaller and more general elements, then it will be easier for him or her to organize them in an order from the most simple to most complex. The idea is that the simpler elements are necessary before learning more complex elements, and the completion of a complex task is impossible without mastering all subordinate elements. To do this, a learner should learn a simple and fundamental piece of knowledge and then get tested on it. Then the learner should learn a harder piece and get tested on it. Then again get tested on the previously learned lower level piece of knowledge, and so forth. A learner builds up his or her knowledge as instruction unfolds.

Case study to showcase strengths and weaknesses of LHA

In their article "Formative evaluation applied to a learning hierarchy" (1978), White & Gagné demonstrated how they applied LHA to make a useful formative evaluation of the course. This study is also used by Dick (1980) to simplify the procedure of formative evaluation. In the study, 148 secondary education students (approximately 50% boys and 50% girls) from three different high schools were completing a test consisting of 47 items that checked the knowledge of 17 elements in the hierarchy of the graphical skills in kinematics. It was a posttest, meaning that there was no prior purposeful instruction to the students, they were supposed to know the content from what they overall learned in the course.

However, the posttest was created with the idea that certain skills are subordinate and certain things are superordinate. White & Gagné (1978) did the posttest in order to see how well students did on the subordinate and superordinate skills. The logic was: if students fail on exhibiting subordinate skills, then they should also fail on demonstrating superordinate skills. The purpose of the study of the results then was to improve the current teaching of kinematics by reorganizing the order of certain learning sets in the study program.

For the most part, students exhibited the consistency that the researchers predicted: if students failed on the lower level skills, they failed on the higher level skills as well. Nonetheless, in some cases this was not the case: in some instances, the hierarchical relationship did not justify itself, and students showed superordinate skills correctly while giving incorrect answers on subordinate skills. White & Gagné (1978) attributed this phenomenon to either issues of recollection or instances of students' misunderstanding of some test questions (p. 93). Dick (1980) explains what this failed hierarchical relationship can mean for instructional designers. It creates the need, he says, "to question the appropriateness and sequencing of the skills which have been identified" (Dick, 1980, p. 283). In other words, the instruction should be reorganized.

I will further use this case study to examine the strengths and weaknesses of LHA. In general, this case study did not question the validity of LHA, it assumed that LHA is the right technique for task analysis and breaking down the content into smaller learning sets. I find it the biggest drawback of White & Gagné's approach, i.e. the fact that they designed a study not to provide evidence for LHA but to promote LHA as a practical tool in improving instruction.

Strengths of LHA

As such, LHA has advantages: it is a logical way of identifying what content needs to be covered in order to reach the goals and objectives of a particular course. LHA helps chunk the content into learning sets and identify in what order these sets should be taught. In this way, LHA helps sequence instruction in accordance with the growing complexity of subject matter. According to Jonassen, Tessmer, & Hannum (1999), there is another big advantage: LHA "[r]emoves nonessential content, making the instruction more efficient" (p. 85). This last one is a

big advantage and helps take into account the fact that a teacher and/or subject matter expert may not be able to limit themselves while teaching. They may also be oblivious that students may be overloaded with information. LHA is both a liberating and constraining technique, because it allows to provide only such content that will speak directly to the final learning outcomes. Finally, the biggest strength is also the apparent simplicity of the approach: it only requires that a subject matter expert and instructional designer identify how a bulk of knowledge can be divided and subdivided into smaller pieces and then sequenced in the best order for students.

Weaknesses of LHA

The criticism of the learning hierarchy model is manifold. Most of its weaknesses have to do with its linearity and idealism, as though knowledge exists in a vacuum rather than in a world in particular contexts.

Jonassen, Tessmer, & Hannum (1999) identify three disadvantages of LHA: (a) it is not all-encompassing, (b) it does not identify prerequisite skills for metacognition and mental models, and (c) it does not take into account other learning outcomes that may appear as instructional strategies are refined for the prerequisites (p. 85). As can be seen, this criticism has to do with the limitedness of the approach: it leaves out metacognition, it is not generalizable to all contexts, and it is not sensitive to quick changes in learning outcomes if needs for such changes emerge.

White (1973) suggests that in reality LHA does not explain why learners often perform complex tasks and fail on simpler tasks, why random forgetting of lower level elements happens, why learning sets are necessarily interconnected and are subordinate or superordinate to each other, how unrelated pieces of knowledge can foster learning of more complex tasks, how incidental learning and learning outside the school context can help in learning other subjects, how automated learning of more complex elements on the basis of lower level skills happens, why specifically more complex elements are learned only after simpler ones. With the last one, White (1973) states that "correlated skills need not be hierarchically related" (p. 365). What is more, White (1973) points to another limitation that has to do with subject-matter: most studies deal with maths and physics, which cannot explain the knowledge that learners acquire in all other disciplines (p. 368). He continues, "[A]n association between two elements is not sufficient to imply a hierarchical relation between them" (White, 1973, p. 369). His final piece of criticism was that sampling in Gagné's studies wasn't big enough (White, 1973, p. 371).

If we go back to the case study described in a previous section, we can see that the sampling size was appropriate for the study, yet the course content was related to physics—the content where it was easier to identify a hierarchy of subordinate and superordinate skills. Also, in the instances where higher order skills were showed but lower level skills that underlie those higher skills were not demonstrated, Gagné did not question the hierarchical nature of those skills, he assumed that the sequence was falsely identified and needed to be rectified (he also talked about students' recollections and misunderstanding of test questions). Hence, the discrepancy of LHA for Gagné was external rather than internal.

Bergan (1980) is critical of the interrelations between prerequisite skills and the nature of positive transfer. He writes, "Although the view that prerequisite skills facilitate the acquisition of superordinate skills is fundamental to the learning-hierarchy model, this assumption has rarely been tested" (Bergan, 1980, p. 640). Moreover, he mentions that the original Gagné's model leaves no room for environmental variables in learning, nor for individual characteristics of learners (Bergan, 1980, p. 643). In contrast, he suggests another alternative to hierarchies analysis—a structure analysis. In this model, different skills to be mastered are not hierarchical

but resemble more a spider web, where one skill does not have only one, but multiple origins (Bergan, 1980, p. 635).

In the above-mentioned case study, we see that Gagné designed a posttest which linked certain higher order skills only to one subordinate skills. His model did not allow him to see that the reason why some students scored right on superordinate skills and failed on subordinate skills could be that the source of that superordinate skill was in a different, perhaps adjacent, piece of knowledge or even discipline. The positive transfer may have happened not only from subordinate skills to superordinate but also from knowledge from outside the system.

No model is perfect, but it seems a counterproductive idea to think about learning as a linear process that has strict hierarchies. While the overall metaphor of a pyramid of knowledge which a student may build up by learning prerequisites may be solid and appealing, the variety of learning experiences in a classroom is much more complicated and intertwined with other courses and life outside the school. Leaning is an organic process rather than schematic, in which sense the metaphor of the spider web seems to be more appropriate.

Conclusions

Gagne's model of a task analysis which he called a learning hierarchies analysis (LHA) was developed in the early 1960s and revised within the next 20 years. It presents an intuitively pleasant model of a step-by-step and hierarchical knowledge acquisition process for hard sciences classes. If we assume that intellectual skills are organized in an ordered manner, LHA may be an ideal way of organizing learning material for students.

However, I think in concert with the research by different scholars that learning is not only a cumulative effect of each sequenced piece of instruction. It rather happens in a multitude of ways. In humanities, LHA can hardly be used to design a lesson or a module. Therefore, I would restrict the practical use of LHA to curriculum development, as was the initial Gagné's idea. LHA is a plausible and feasible framework that can be uses on a macro-level. Because of its linearity and limited view of knowledge acquisition in real life, LHA creates rigid boundaries as to what students learn and how they learn. Knowledge is barely strictly hierarchical. On a micro-level, a structure analysis as suggested by Bergman (1980) instead of LHA is more justified for practical use.

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