Developing a Learning Hierarchy for Identifying Pre-Requisites to Training Goals in Vocational Education

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Abstract—From the perspective of cognitivism, any complex learning task can be broken down into its supporting components which when acquired will lead to the learning of the complex task. Failure to identify the supporting components will lead to non-achievement of the intended learning goal. The procedural task analysis and the learning task analysis technique are techniques that can be used to analyse learning or training demand which would lead to a better understanding of pre-requisites to an intended learning/training goal. This paper provides an example of how procedural task analysis and the learning task analysis techniques can be used to identify the pre-requisites to a learning goal for a vocational skill training course in mechanical engineering.

Keywords—learning hierarchy technique; learning outcome; skills training

I. INTRODUCTION

Instructors in Technical and Vocational Education and Training (TVET) often assume that trainees will be able to apply what have been taught to them [1], underestimating the complexity of a given training or learning task given to trainees [2]. As a consequence, instructors fail to appreciate the full range of supporting skills that are needed to achieve the specific learning task leading to ineffective instructional efforts.

According to [3], a cognitivist psychologist and founder of instructional design, any complex training or learning task has pre-requisites that must be taught and acquired by trainees to support the accomplishment of the task. Gagné categorizes a skill into one of five domains namely, intellectual skill, cognitive strategy, verbal information, attitude and motor skill [3]. Intellectual skills refers to the ability to solve problems, discriminate between facts, concepts and principles; while cognitive strategy refers to the ability to use appropriate strategies to monitor progress in problem solving and thinking activities. Verbal information on the other hand refers to the ability to narrate facts of knowledge. Lastly, Gagne’s definitions of attitude and motor skill are similar to the affective and psychomotor domains as defined by Bloom [4].

Learning tasks in TVET is often job related and thus many TVET courses are dominated by motor skills demonstrations. Nonetheless, the ability to demonstrate these motor skills are also dependent on skills acquired from the other two domains [5]; the fact that instructors often missed. For example to be good at arc welding (learning outcome in the psychomotor domain), one needs to know the associated procedures (cognitive skills) and to actually want to learn to perform the task in the first place (affective skills). Thus, the dominant motor skill goal is achieved through the support of cognitive and affective skills which must precede the dominant goal. In short, although learning/training can be targeted at a particular learning domain, other domains are also invoked in the process of achieving a particular learning goal.

One factor that leads to the poor appreciation of the complexity of a training task is the lack of instructional design knowledge and skills among instructors in TVET [6]. Instructional design knowledge serves to inform an instructor on the importance of planning for instruction through a proper analysis of the job and learning content before implementing instructions [7]. Since, training tasks in TVET are related to job tasks, instructors also need to understand the demand of the job task – achieved through task procedural analysis - before the training demands can be appropriately identified. Thus the purpose of this paper is to illustrate the application of two related analysis techniques – procedural task analysis and learning task analysis – that can be used to identify important pre-requisites for a specific higher level learning outcome using an example from a unit on automotive air conditioning installation in a mechanical engineering course. The scope of this paper is limited to design and development excluding impact evaluation on actual setting.

II. PROCEDURAL TASK ANALYSIS: CONCEPT, PROCEDURE AND ILLUSTRATION

Procedural task analysis is a process of analyzing the sequence of steps in a performance-based task. Performance-based task is typical in TVET where trainees are expected to accomplish a task that is related to a specific occupation [8]. Before a task can be understood for teaching purposes however, the instructor has to identify the sub-tasks related to the main task. Thus, to identify the sub-task and sequence of activities involved, a procedural task analysis must first be conducted [9]. The sub-tasks can then be further analyzed to identify their training/learning pre-requisites [10]. The outcome of the procedural task analysis is a flow chart of the associated sub-tasks. The application of the procedural task analysis
technique in TVET is here illustrated on automotive air conditioning installation task; a unit from a mechanical engineering course.

The procedural task analysis is conducted by asking the first question and a follow up question. For this specific unit, the first question is, “What should be the first activity in a test and commission task?” and the follow up question is, “What is the next activity”. The follow up question is asked till completion [11]. The answer to the first question is “taking safety precautions” and the next activity is “troubleshooting” to the car air conditioning system. If the system did not show any failure symptoms, routine maintenance will be conducted. If otherwise, the failing component is replaced with a new one. Upon completion, test and commission will be conducted to make sure the system is running properly. All the activities and their sequences are shown in Fig 1.

II. LEARNING TASK ANALYSIS: CONCEPT, PROCEDURE AND ILLUSTRATION

In contrast to a procedural task analysis, a learning task analysis is the process of linking the learning outcome and identifying the pre-requisites performance of learning [12]. As a result of the analysis, a learning hierarchy that consists of the skills requirements for the achievement of specific learning task will be developed. Thus the learning analysis technique is also known as the learning hierarchy technique [12]. The learning hierarchy technique is based on the assumption that learning occur in a hierarchical manner. According to (Gagné, 1985), learning at a higher level is built from previous knowledge which is lower level to the higher level knowledge of learning. Basically, a learning hierarchy illustrates the relationship between the lower level (pre-requisites) and the higher skills. In a follow up work by [13], the learning hierarchy technique is described as,

... a top-down analysis technique that can be used by an instructional designer (or a teacher) to identify the pre-requisites for an expected learning outcome (learning objective) in the intellectual learning domain. The top-down analysis of the top-most expected learning outcome would result in a set of subordinate intellectual skills that are related to each other in a hierarchical manner. The top-most expected learning outcome is known as the terminal objective while the subordinate objectives are known as the enabling objective [13].

The emphasis of the learning hierarchy technique has always been on the intellectual domain and was first introduced in the development of a military training program by Gagné’ [14]. However, since then many efforts have been made to establish its usefulness in TVET [13], [15]–[17]. The assumption behind the technique is that, trainees need to master the pre-requisite skills before they can proceed to the next higher level skill. Knowledge gained from using the technique is in the form of comprehensive skills profiles and their hierarchical relationships which will help instructors to meet the needs of trainees with low cognitive skills who are often enrolled in TVET programs. Although, the technique has been used predominantly for the intellectual domain, the technique is equally useful for identifying skills pre-requisites of the other domains as illustrated by the example in this paper.

The illustration given next is based on the procedural task analysis result obtained previously in Fig. 1. Based on the flow chart in Fig. 1, an activity was chosen and translated into a learning outcome. The activity chosen is “troubleshooting” and the goal of learning is “to be able to troubleshoot air conditioning (A/C) system”. The terminal goal is the highest goal to be achieved while the lower level goals are the enabling objectives. The next higher level objective in a hierarchy is the super-ordinate objective to the lower sub-ordinate objective [3]. To complete the lower level skills in the learning hierarchy, Gagné proposes that instructor asks the question, “What should learner be able to do in order to be able to learn the task stated in the super-ordinate objective”. This process is done iteratively to complete the learning hierarchy.

Upon completion of the learning task analysis process, the learning hierarchy in Fig. 2 is constructed which represents the hierarchical relationship between the knowledge and skills related to the top most objective. From the hierarchy, it can be seen that for a trainee to be able to learn to troubleshoot an AC system, they must have acquired the three learning outcomes namely, “able to conduct routine maintenance”, “able to conduct repair” and “able to conduct commissioning”. These three skills on the other hand can only be acquired if they have already acquired the sub-ordinate skills shown. Furthermore, from the hierarchy it can be seen that although a trainee will be using his/her hands-on skills (motor skills) to trouble shoot a non functioning AC system, to learn this skill, trainees need to

![Fig. 1. Procedural task analysis for automotive air conditioning installation in Mechanical Engineering course](image)
have the supporting skills that are in the cognitive as well as in the affective domain. As an example, before a trainee can learn how to conduct repair, he/she must be “able to understand the manual” and he/she must also be “willing to conduct the repairs” (which is an attitudinal dimension to learning). To identify the necessary attitude dimension, we need to ask the question “what kind of attitude do they need to have in order to learn the new task?” Thus, completing the iterative analysis process will result in a learning hierarchy that shows the relationship between pre-requisite skills and the learning outcomes which can be used to help instructor design appropriate instructions. In this particular example, the learning hierarchy has highlighted the importance of cognitive skills and attitudes as pre-requisites to the hands on skills on troubleshooting which is the targeted learning outcome.

The usefulness of the skills identifications through the techniques is not limited to designing and sequencing instructions but also useful for constructing assessment items especially in formative or diagnostic testing. The learning task analysis in Fig. 2 however, only gives the skills profiles for three domains (intellectual, affective and motor skills domains) excluding the verbal information domain and cognitive strategies domain to reduce the complexities of the hierarchy. The task can be further analyzed to identify those skills.

![Fig. 2. A learning hierarchy derived through a learning task analysis](image)

**IV. CONCLUSION**

This paper attempts to promote the use of a systematic design approach in designing instructions in TVET. Two potential techniques that can be used at the initial stage of developing instructions namely, procedural task analysis and learning task analysis technique are proposed. Procedural task analysis provides information on the sub-tasks that are involved in a given job task while a learning analysis on a task provides information on the pre-requisites to learning a given task. Examples on the application of the two techniques are given using a course unit in mechanical engineering. The learning analysis technique has successfully illustrated the diverse and associated pre-requisites that are required for a seemingly motor skills learning. While both analysis techniques are relevant to TVET instructors, the learning task analysis through its systematic identifications of skills provides the detailed picture of supporting skills and their hierarchical relationships that are essential for making decisions on the skills to be developed as well as for sequencing of training. This study illustrated part of an instructional design process that result in potential teaching and learning material. The efficacy of the learning material will need to be access in a different study that look into cause and effect relationship between learning material and academic achievement.

**REFERENCES**


