Development of a Competency-Based Introductory Course in Fluid Power

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Abstract

A project to develop a novel curriculum for the associate degree in manufacturing engineering technology has been funded by the National Science Foundation. The Sinclair Community College in Dayton, OH, coordinates the development work of the course. The focus of the curriculum development process is to create an industry-driven, competency-based, modularly structured, and integrated curriculum.

One of the last modules to be developed is the fluid power module, which is scheduled for six weeks in the fourth quarter (out of six). It allocates 20 contact hours for this introductory program in industrial fluid power. As in all other modules, the competencies developed by participants (students) meet the needs of manufacturing industries for manufacturing technicians with appropriate skills and knowledge.

A team from industry and academia has developed a set of competencies in fluid power. The competencies guide the participant to develop necessary skills and knowledge. They also imply that a person can demonstrate competency in ways going beyond the traditional curricula. Emphasis is on what the course participant can do. The tasks to be completed by participants are focused on enhancing the problem solving skills.

The curriculum is modularly structured, which means that the program is delivered in a very flexible manner. The flexibility is enhanced by the fact that the modules are smaller than three semester-hour credit courses. As part of the integrated curriculum, the fluid power module is interconnected with other modules. The relevance of the competencies developed in various modules is thus reinforced throughout the curriculum. As a result, the participant of the program (traditionally known as student) is expected to be able to relate each of the competencies to the manufacturing engineering.

1. Background

The National Science Foundation has been funding since 1995 three national Centers of Excellence through its Advanced Technological Education (ATE) Program in the Division of Undergraduate Education. One of the centers is located within the Advanced Integrated Manufacturing Center (AIM Center) in Dayton, Ohio, as a partnership of Sinclair Community College an the University of Dayton.

The ATE Program promotes exemplary improvements in advanced technological education at the national and regional level. Its focus is on supporting curriculum development and program improvement for educating technicians for the high-performance workplace. The program includes opportunities for technicians already employed in industry or enrolled at four-year colleges and universities.

The goal of the program is to develop an activity-based, competency-based, contextual, industry-verified, and modular curriculum in manufacturing engineering technology. This approach may lead to systemic change of technology education of technicians in the United States. The curriculum employs a novel pedagogy approach in which learning happens through a series of authentic learning tasks (ALTs). The emphasis is on learning by doing. The modules are usually smaller than traditional courses to allow for flexibility in the program execution and to make the assessment easier.

The ALTs require new assessment methods to get information about the performance of the participants, to predict how they would perform in the advanced technological workplace. For each of the course modules, a set of performance standards has been developed to evaluate the level of competence of each participant. While curriculum details may vary from institution to institution, the core competencies are expected from all participants. The manufacturing engineering technician is expected to have a broad knowledge to be able to support other manufacturing professional.

The manufacturing engineering technician will be a key member of a manufacturing team in a company. The team will be responsible for planning and control of the production, management of the production operations, quality, and maintenance. The job will require a constant contact with other manufacturing teams, and with customers.

2. Development of the Curriculum for Fluid Power

The work on the development of the curriculum started with the preparation of the competency list. A fluid power industry profile was prepared to provide participants (traditionally known as students) with a general idea before they start to work on their competencies. The industry profile describes an actual company that implements the module competencies. For the fluid power module ten competencies were developed. In the process, several prerequisite modules were indicated, which would contribute to the fluid power module. Then, six authentic learning tasks (ALTs) were found that incorporated all of the ten competencies. Each ALT served to develop several competencies, so that the participants would strengthen their ten competencies as they proceeded from one ALT to another. A transfer activity was selected that would be executed at the end of the module. The transfer activity incorporates all of the competencies and gives the participants a chance to practice what they have learned. It also serves to evaluate participants' overall performance in the fluid power module.

2.1. Prerequisite modules

- Units and Conversions
- Product Development Testing
- Electrical and Electronic Controls
- Robots and Programmable Logic Controllers

In addition, participants are expected to demonstrate understanding of:

- Fundamental pneumatic principles
- Fundamental principles of vacuum
- Fundamental hydraulic principles

2.2. Competencies of the fluid power module

- Describe and calculate how the pressure and flow of a fluid relates to the functioning of a hydraulic actuator (Comp. 1).
- Demonstrate an understanding of forces, pressures, power, energy conversion, efficiencies of components, and energy losses due to friction, slippage, and leakage, including the effect of energy storage on efficiency and size of power units (energy converters) (Comp. 2).
- Predict the performance of an actuator under meter-in, meter-out conditions and bleed-off circuits (Comp. 3).
- Read and interpret hydraulic and pneumatic schematics and model codes (Comp. 4).
- Specify an o-ring size, material, and oil capability for a specific application (Comp. 5).
- Specify a hydraulic power unit (HPU) considering pressure, flow (power), heat, dissipation, filtration, fluid, and maintenance (Comp. 6).
- Demonstrate an understanding of proportional controls related to fluid power, and decide when and why to use electromechanical, pneumatic, and hydraulic actuation (Comp. 7).
- Discuss safety and environmental concerns related to fluid power such as leakage, noise, reclaiming, and disposal (Comp. 8).
- Demonstrate an understanding of the fundamental principles of pneumatics, hydraulics, and vacuum technology (Comp. 9).

- Demonstrate an understanding of cost issues when selecting hydraulic, pneumatic, and vacuum components (Comp. 10).

2.3. Authentic Learning Tasks (ALTs)

- Hydraulic and pneumatic schematics, performance of fluid power components, force on cylinders (ALT # 1, Comps. 1,2,3,4,6).
- Hydraulic and pneumatic cylinders, speed, pressure, and load calculations and verification in lab, discuss safety procedures and environmental factors (ALT #2, Comps. 1,2,3,4,8,10).
- Seals, fluid compatibility, fire resistant fluids (ALT #3, Comps. 5,6,8,9,10).
- Computer simulation of fluid power schematics (ALT #4, Comps. 1,3,4).
- Hydraulic power units, filtration, efficiency (ALT #5, Comps. 2,4,6,10).
- Directional control valves (ALT #6, Comps. 1,2,3,6,7,8,9,10).
- Develop a work cell that uses fluid power (Transfer Activity, Comps. 1-10).

2.4. Assessment

The goal of the curriculum is that the learning experiences are competency-based and that the assessment is authentic. Three levels of participant's (student's) performance are expected:

- Needs Improvement
- Competent
- Highly Competent

Participants are expected to perform at least at the Competent level on each rating factor for each authentic learning task and transfer activity. The Highly Competent level recognizes performance that is significantly better than Competent. Table 1 lists criteria for the three levels of competency in the troubleshooting of a fluid power system. Participants were asked to provide a deliverable in the form of Data Sheets: Component Functionality, Component Descriptions, and Troubleshooting Practice.

Table 1. Assessment criteria for ALT #1

Participant **Deliverable**	**Highly Competent**	**Competent**	**Needs Improvement**
Data Sheet: Component Functionality, (Comp. 1,2,6)		Calculations of cylinder force, and piston velocity during extension and retraction are correct, and with proper units.	Calculations of cylinder force, and piston velocity during extension and retraction are incorrect or missing, or units are not correct.
Data Sheet: Component Functionality, (Comp. 1, 2, 6)		Calculations of hydraulic motor speed are correct, and with proper units.	Calculations of hydraulic motor speed are incorrect or missing, or units are not correct.
Data Sheet: Component Descriptions, Questions 3 (Comp. 4)	The pressure and flow ratings of the component are identified, rated, and referenced correctly. Model codes are complete, correct, and show an in-depth knowledge of hydraulic components.	At least 80% of the component's model code is identified, correctly. The pressure and flow ratings of the component are identified, rated, and referenced correctly.	The pressure and flow ratings of the component are not identified, rated, and referenced correctly, or are missing. The identification of the model code lacks basic understanding of the component, or is missing.
Data Sheet: Troubleshooting (Comp. 1, 2, 3)		Proper troubleshooting techniques are listed and applied. Possible reasons for malfunction are identified. Measurements to determine possible causes are described, and all tests that should <u>not</u> be performed are listed.	Troubleshooting techniques are missing or incorrect. Possible reasons for malfunction are missing, or measurements descriptions are incorrect or missing, or the list of tests that should <u>not</u> be performed is missing or incomplete.

Data Sheet: Troubleshooting Practice, schematics (Comp. 1, 2, 3)	Schematics are all correct, exceptionally complete, detailed, and neatly drawn.	At least two of the three diagrams are complete and correctly labeled.	Diagrams are incorrect or missing
Data Sheet: Troubleshooting Practice, fault ID and location (Comp. 1, 2, 3)	All three faults in the schematics are identified correctly. How faults were located is described in detail and shows an in-depth understanding of fluid power schematics.	At least two of the three faults in the schematics are identified correctly. How faults were located is described adequately and shows a basic understanding of fluid power schematics.	Faults are identified incorrectly, or how faults were located is inadequately described or missing
Data Sheet: Component Descriptions, Questions 1 and 2 (Comp. 4)	All components are identified, rated, and referenced correctly. Descriptions and sketches are complete, correct, and show an in-depth knowledge of hydraulic components.	At least 80% of components are identified, rated, and referenced correctly. Descriptions and sketches are correct, and show a basic knowledge of hydraulic components.	List of components is incorrect or missing. Descriptions or sketches are incomplete or missing, or ratings and references are incorrect.

3. Advantages of This Approach

There are a number of advantages of using competency-based learning in a laboratory:

- The emphasis is on understanding, not memorizing, or completing without thinking, the laboratory procedures. This promotes discussions and collaboration among participants, and facilitator mentoring.
- The facilitator also becomes more involved in participants' work. He coaches, mediates, consults, and provides expertise. He is available when asked, or when he notices the need to be involved. Otherwise, the facilitator remains on the side.
- Participants feel responsible for providing answers to the problems provided in the Data Sheets and those they encounter themselves. They develop skills to solve these problems, and thus become more competent.

- Teamwork is encouraged, which helps develop interpersonal skills, which are of benefit in an industrial environment.
- Laboratory time is used efficiently, with all participants fully engaged in the learning process.
- Enables to expose weak spots in participants' knowledge and address them right away.
- Teaches participants take responsibility for their learning. Even with the facilitator's help, participants are required to understand and solve the problems.
- Participants leave the lab more mature and confident about their skills. They know they can solve other problems when they encounter them in other modules, or later in industry.

4. Disadvantages of This Approach

Competency-based learning comes with the following disadvantages:

- Since competency-based learning stresses quality, not quantity, of content covered, some of the material covered by textbooks may be omitted.
- Participants may initially struggle with competency-based learning when this approach is new to them. They may not be prepared to answer questions posed by the facilitator, they may want the facilitator to solve all the problems for them.
- It can be difficult and time-consuming to correct erroneous participant reasoning, and keep participants on track.
- Participant assessment is more difficult than traditional multiple-choice tests. It requires preparation of different assessment tools. Even when a standard curriculum module is available, the facilitator needs to adapt it to local conditions and available laboratory equipment.

5. Conclusion

In January 2002 the work on the fluid power module presented in this paper was still ongoing, with possible modifications of the module content. One problem that occurs in all authentic learning tasks is the need to limit the topics covered so that the total number of hours for the module does not exceed the suggested limit of 20 hours. Fluid power courses taught at colleges are among the most difficult, and are loaded with theory and practice. The challenge during the preparation of the fluid power module for a competency-based curriculum was how to create a learning environment for the participants, and select what is most important in fluid power.

6. Acknowledgments

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