

The Use of “How Does It Work?” Type Projects in a Mechanical Engineering Program

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ABSTRACT

“How Does It Work?” type project involve a student or a group of students being assigned an engineering device or system to study. They must gather information about how it works, on how it is implemented and on whether any problems have been encountered with the device or system during its operation and they must then prepare a report and/or presentation on their findings. In gathering the required information, the students must use the Web and books including handbooks and manuals, consult with trades-people involved with maintaining and repairing devices or systems of the type being considered and they must arrange to view examples of the device or system and take suitable photographs to complement the other information they have gathered. The latter requires that examples of the device or system be in use within a reasonable distance of the academic institution at which the student is studying. Devices and systems that are suitable for such projects are often in use by the academic institution itself. Examples of suitable project topics are discussed in this report and some details of typical projects of this type are discussed here. A discussion of the way in which “How Does It Work?” type projects can be incorporated into design and engineering science courses to help illustrate the practical application of the course material is also presented. The advantages and disadvantages of projects of this type will also be discussed.

INTRODUCTION

One of the characteristics of most successful engineers is a curiosity about how devices and systems work and about how they are constructed. It would seem that this characteristic should be encouraged and used in engineering education programs. “Deconstruction” projects, in which a device is disassembled and a report on how it works and how it is constructed do, of course, help develop this characteristic. Such projects can also give the student good practical experience and experience of working in a team situation. When both written and oral reports are required as part of the project, such projects can also assist in the development of communications skills. However, such deconstruction projects are often time-consuming to implement in that the devices to be disassembled have to be gathered. Such projects also require that the students have access to the tools required for the disassembly and that a suitable area in which the disassembly is undertaken be available. In addition in many cases where this type of project is used, the devices that are disassembled are relatively simple and sometimes leave the student with the impression that engineering devices are all simple and easily understood. In order to supplement design-build and device deconstruction projects, an

attempt was made to introduce “How Does It Work?” type projects. In the initial implementation of these projects, a student or group of students were assigned a device or system and using the library and the web, they gathered information on how such devices operate and how they are constructed. The students then prepared a written report describing the device and how it works. They also had to give an oral report to the class describing their findings. Typical of the devices considered in these projects were:

1. TV remote control.
2. GPS navigational system.
3. Aircraft gas turbine engine.
4. Automotive automatic transmission.
5. Fuel cell.
6. Solar hot water system.
7. Residential air-conditioning system.

While the students responded quite enthusiastically to these projects and while it did expose them to more complex devices and systems than most design-build and deconstruction projects, it was clear that in many cases the students had not developed an appreciation of the practical problems that had obviously arisen in implementing the device and that, if they had not encountered an actual device of the type being considered, they often had little real appreciation of what it looked like and of how well it operated. It was clear therefore that the “How Does It Work?” type project experience should be extended to include contact with an example of the device being considered.

The use of projects of various types in engineering education has been widely discussed. Experience has indicated that, whenever possible, these projects should deal with real world problems. While this is relatively easy to do in the final year program particularly in the capstone design project, it is often not easy to do in the earlier years. “How Does It Work?” type projects offer a way of doing this, i.e., of exposing the students to real world devices and systems in the earlier years of their program.

EXTENDED “How Does It Work?” TYPE PROJECTS

The initial experience with “How Does It Work?” type project suggested the need to have contact with an example of the device being described. The projects were therefore extended to require that the student groups, in gathering the required information, must continue to use the Web and books, including handbooks and manuals, but must also consult with trades-people involved with maintaining and repairing the device or system being considered and that they must arrange to view examples of the device or system and take suitable photographs to complement the other information they have gathered from other sources. The latter requires that examples of the device or system be in use within a reasonable distance of the academic institution at which the student is studying which limits the range of devices that can be considered. However, devices and systems that are suitable for such projects are often in use by the academic institution itself.

Contact with the trades-people in gathering the project information has additional benefits. For many of the students involved it is their first real professional contact with technicians who are such an important element in real engineering teams. The trades-people also can provide the student groups with information about problems experienced during the long-term operation of the device or system. The students are encouraged to incorporate information of this type into their reports.

EXAMPLES OF “How Does It Work?” TYPE PROJECTS

Some examples of devices that can be used in “How Does It Work?” type projects are discussed below. These examples are most applicable in a Mechanical Engineering program. However, similar projects that can be used in other programs can easily be identified.

Small Cogeneration System: Many universities have installed or are now installing relatively small gas turbine based cogeneration systems to supply part of their electrical and heating loads. The layout of such a system is shown schematically in Fig. 1. In using this type of system for their project, the student group first studies how such systems operate and why they have been installed. They do this using the web and books. They then arrange to tour the facility and to meet with the person who is in charge of the operation of the device. During the tour they photograph the facility and in the meeting with the operator they ask questions about the reliability of the system and about problems that have been encountered in its operation. They also ask if they can look through any available manuals that may be available and copy diagrams and photographs that show mechanical details of the device. The students then prepare a report describing the device, its operation and the reasons for its installation. They also prepare a Power point type presentation highlighting the main features of their report. This presentation is given to the rest of the class.

Residential Furnace: Most companies that sell residential furnaces also install and service such furnaces. Such companies are invaluable sources of information about such devices. Examples of a wide range of such systems are also available in houses in many countries. In using this type of system for their project, the student group first studies the various types of systems that are available and how such systems operate. They then arrange to visit one or more local companies that sell residential furnaces and to meet with salespersons and with technicians who install and repair such furnaces. During the meeting with the salespersons, the students gather brochures that describe various types of furnaces and that give drawings and photographs of the internal construction of the furnaces. During the meeting with the technician(s) the students discuss problems and difficulties that have been encountered in the installation and operation of the furnaces. They also try to arrange a visit with a technician to a furnace system that is either being installed or serviced. The students then prepare a report describing the device and its operation and a presentation that is given to the rest of the class.

Helicopter Rotor Hub System: A helicopter rotor hub system and the way it is operated by the pilot using the controls in the cockpit seems to be of considerable interest to many engineering and is thus a very suitable topic for a “How Does It Work?” type project. A simple schematic drawing of a rotor hub swash-plate system is shown in Fig. 2. Many airports, even those that are quite small, have a company that operates at least one small or medium size operation. Military helicopters also at times fly into civilian airports and remain there for one or two days. In both of these situations it is usually possible to arrange to have students view a helicopter and have a pilot demonstrate the use of the cyclic and collective controls. In many cases, the pilots will also be willing to give short flying demonstrations. . In using this type of system for their project, the student group first studies, using information on the web and in books, how such a system operates and some of the ways in which the system is implemented. The students then arrange to view a helicopter and talk to a pilot and, if possible, a technician who services the helicopter. During this visit they will take photographs showing the rotor hub details. They will discuss the effectiveness of the system and any problems that are encountered in its operation with the pilot

and the technician. The students then prepare a report describing the device and its operation and a presentation that is given to the rest of the class.



Figure 2 – An example of a helicopter rotor hub.

Examples of other suitable project topics are:

1. Small Hydro Electric Plant
2. Elevator and/or Escalator
3. Residential Air-conditioning System
4. Photo-Voltaic Electrical Generating System
5. Wind-Turbine System
6. Solar Hot Water System
7. Residential Washing Machine
8. Residential Clothes Dryer
9. Residential Dishwasher
10. Microwave Oven
11. Automobile Automatic Transmission
12. Natural Gas Pipeline Pumping Station

PROS AND CONS OF “How Does It Work?” TYPE PROJECTS

Projects of the “How Does It Work?” type are, of course, intended to complement, not replace design-build and deconstruction type projects. Among the advantages of “How Does It Work?” projects are:

1. They expose the student to engineering devices normally not dealt with in the other two types of project.
2. They expose the student to relatively complex, real-world engineering devices and systems.
3. They expose the student to devices that require a knowledge of the various engineering sciences in order to understand their operation.

4. If they are implemented in the correct manner, they can expose the student to operational problems encountered in the use of the device or system.
5. If they are implemented in the correct manner, they can cause the student to interact with technicians and with other personnel likely to be encountered in a full engineering team.
6. The projects, if well planned, can be used to complement work being undertaken in other courses.

Among the disadvantages of “How Does It Work?” projects are:

1. They do not basically require that the students utilize any creativity or problem solving skills. This can be partly overcome by requiring that the students in their reports discuss modifications that should be made to the device or system in the light of actual operating experience. However, not all of the projects are suitable for this activity.
2. They can require a considerable amount of organizational effort in identifying suitable devices and systems, to get the agreement of those involved to allow the students to visit the site of the device or system, to get the agreement of those involved to discuss the device or system with the students, to arrange or at least check the transportation to and from the site and to ensure that the students follow all required safety procedures when visiting the site.
3. The projects must be matched to the students’ knowledge and this can impose significant limitations on range of available projects.
4. The interaction of the students with the personnel involved has to be monitored to ensure that no problems are developing.

INCORPORATION INTO BASIC COURSES

Project work of the type being discussed here is usually incorporated in design related courses where they can be used to complement conventional design and design build projects. However, “How Does It Work?” projects can also be used in conventional engineering sciences courses in order to expose the students to real-world applications of the material being discussed in the course. Examples of this are:

Thermodynamics Course: In thermodynamics courses, “How Does It Work?” projects concerned with various components in an electricity generating plant, with cogeneration systems, with air-compressors, with evaporative cooling systems, with refrigeration and air-conditioning systems and with solar hot water systems can, for example, be used.

Fluid Mechanics Courses: In Fluid Mechanics courses, projects concerned with building ventilation systems, with large fans, with wind-turbine systems, with natural gas transportation systems, with water sprinkler systems in buildings, with wind-tunnels and with aircraft propellers, for example, can be used.

Heat Transfer Courses: In Heat Transfer courses, projects concerned with condensers, with various types of boilers and furnaces, with various forms of solar energy systems, with dehumidification systems, with various types of industrial heat exchangers and with under-floor room heating systems, for example, can be used.

CONCLUSIONS

“How Does It Work?” projects can be used to expose students to relatively complex, real-world engineering devices and systems, they can be used to expose students to operational problems encountered in the use engineering devices or systems, they can lead to interactions between students and technicians and other personnel likely to be encountered in a full engineering team and they can be used to complement other types of projects. They can also be incorporated into engineering science courses where they can be used to expose the students to real-world applications of the material being covered in the course.

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