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Machine Control – A Design and Technology Discipline in Israeli High Schools

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Abstract

This paper presents principles, contents, experience, evaluation and challenges of a new Machine Control discipline developed as part of the technological education reform in Israel. The discipline has been widely implemented in high schools and has the status of an optional matriculation subject.

Keywords: Technology education, machine control, design, high school, matriculation subject, Israel.

1. Introduction

The new discipline Machine Control was developed throughout 1989 and implemented in 1990, as part of the technological education reform in Israel. The principal goal of this reform was to change the total separation between comprehensive and technological schools into a common educational framework, with two clusters of school matriculation subjects: general subjects (obligatory for all students), and optional (majoring) matriculation subjects (for students to choose out of a given cluster). Machine control is included in the cluster of the optional matriculation subjects. Moreover, this discipline has been authorized and accredited as one of six main disciplines preferred by the Israeli universities among other matriculation subjects.

This paper presents principles, contents, experience, evaluation and challenges of the discipline curriculum.

2. General description of the discipline

Machine control was designed to meet the following educational goals:

- development of systems thinking,
- development of technological design skills,
- acquisition of mathematical and scientific backgrounds to be implemented in the processes of systems design and operation,
- acquisition of systems control concepts,
- acquisition of knowledge and experience in control processes of typical technological systems,
- stimulation the skills of self-study, team-work and search for implicit features of the systems.

The curriculum for the discipline is built out of three main parts:

- *Backgrounds* - engineering, mathematical, physical and systems concepts and technological processes,
- *Applications* - systems and processes specific for different technological fields,

- *Workshop* - hands-on practice in design, building and operating control systems and components.

The discipline is studied in the eleventh (240 hours) and twelfth (210 hours) grades. It requires a prerequisite knowledge of a certain level. An additional version of the curriculum is adapted to students with lower achievements (30 extra hours each year).

The modular structure of the discipline curriculum is presented in Fig. 1. It fits requirements of the matriculation certificate, in which a student should accumulate matriculation points (at least twenty), while he/she gets a number of accreditation points for the learning subject. Each subject can be studied at different levels and scopes and therefore accredited with a different number of points. This accreditation can be achieved in several versions of the modular curriculum.

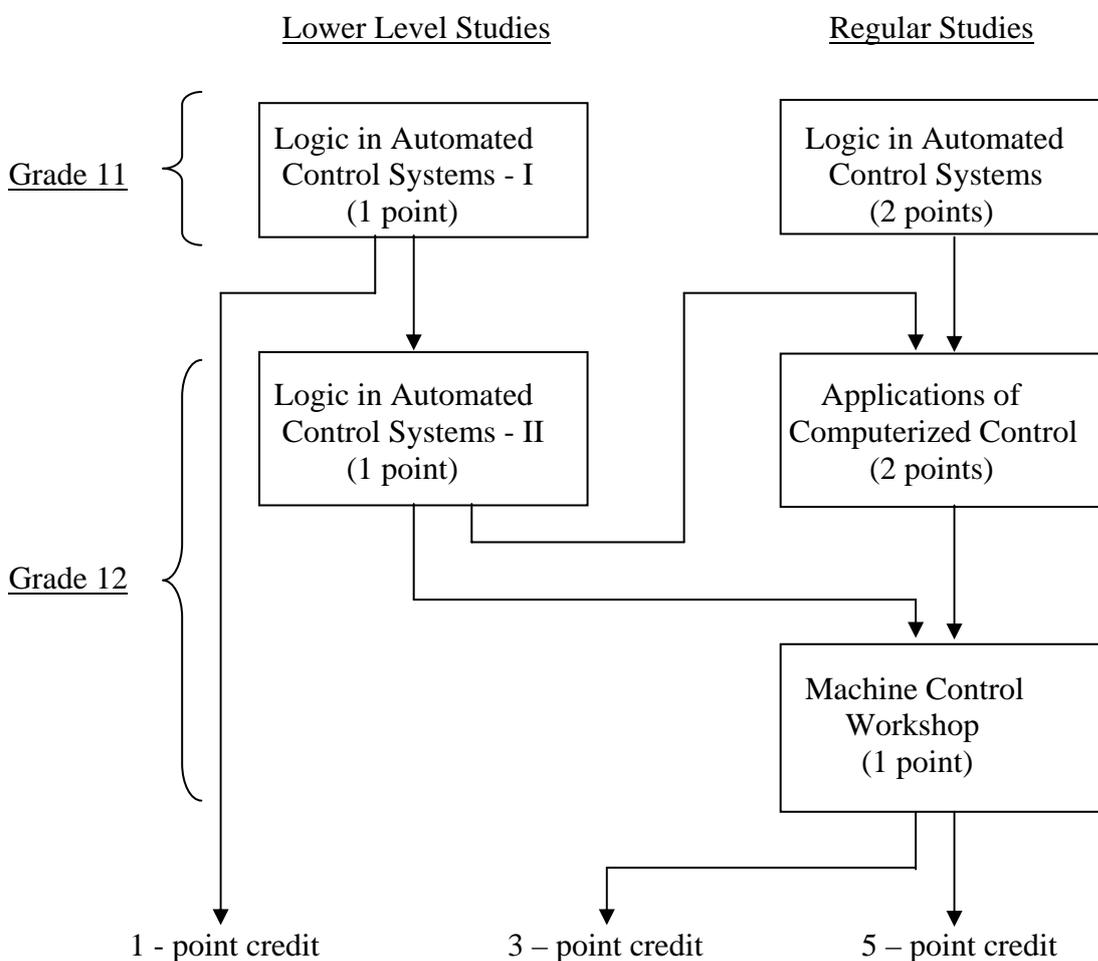


Fig. 1. Modular structure of the Machine Control curriculum

As shown in Fig. 1, the regular studies of the discipline provide the student with five credit points and include three subjects:

- Logic in Automated Control Systems (2 points) at grade 11,
- Applications of Computerized Control (2 points) at grade 12,
- Machine Control Workshop (1 point) at grade 12.

For students with lower prerequisites the study of Logic in Automated Control Systems is divided into two modular parts studied at grades 11 and 12. The student can study only the first part and get one credit point. If the student completes the subject successfully, he/she can join the regular studies group and achieve the full five points accreditation or take only the Machine Control Workshop and graduate with three credit points.

Ten years of experience teaching Machine Control in high schools indicates that about 40% of the students learn Machine Control in the regular studies program and get five point credit, while the others start at lower level studies. About 40% achieve only one credit point, most of them study the discipline in vocational schools. From the remaining 20% half of the students complete with three credit points and the other half study Applications of Computerized Control (2 points) and complete the whole five points program.

3. Contents

The subjects studied in the Logic and Automated Systems regular course are listed in Table 1.

Table 1. Course subjects

	Subjects	Hours
1	Basic System Concepts	
1.1	Introduction to Control	2
1.2	Block Diagrams of System Components	2
1.3	Open and Close Control Loops	5
1.4	Typical Control Processes	4
1.5	Applications of Control Systems	10
1.6	Steady-state Control Systems Response	8
1.7	Dynamic Response of Control Systems	8
1.8	Control System Stability	4
1.9	Computerized Control System	9
2	Logic and Automation	
2.1	Introduction to Automated Systems	4
2.2	Physical Flows Features	7
2.3	Power Sources	10
2.4	Automation Devices and Components	10
2.5	Overview of Binary and Analog Sensors	5
2.6	Actuators	7
2.7	Logic Concepts(Gates, Boolean functions, Carno Maps)	14
2.8	Logic Circuits	10
2.9	Applications of Logic in Controlled Systems	9
2.10	Hydraulic and Pneumatic Systems	22
Total Learning Hours:		150

Learning hours in the course are divided as follows: 60% theoretical and 40% laboratory studies. In the laboratory part, the students are involved in design, building and operating real hydraulic, pneumatic, electrical and integrated controlled systems for different applications.

In the Applications of Computerized Control subject the students deal with systems and processes specific to different technological fields. A series of optional curricula is suggested, so that each student chooses to learn one of the control processes in vehicles, aeronautics, agriculture, marine and CAD/CAM systems. Providing students with this opportunity of multiple choice is considered important to their professional orientation in the engineering and technology fields.

The optional curricula present the latest systems used in the technological fields. The main idea behind the subject is that the student will pass through three educational stages:

- Insight into systems and technologies employed in the selected technological field;
- Exploring the acquired theoretical concepts in the real technological systems;
- Initial design and problem solving practice in the field.

Examples of the systems learned in different fields:

- A vehicle electronic control systems including engine, transmission, breaking and others.
- An airplane flight and navigation systems (automatic pilot).
- An automatic controlled greenhouse including humidity, temperature, light intensity, CO₂, water conductivity, pH and other systems.
- A marine automatic steering system, which includes mechanical, hydraulic, electrical and computer subsystems.
- Computer Integrated Manufacturing (CIM) and Human-Machine Interface (HMI).

Together with field-oriented topics, the optional curricula include a number of common topics such as propulsion systems, motion control, sensor fusion and robotics.

The Machine Control Workshop goal is threefold: to provide extensive hands-on practice with the systems learned in the Applications of Computerized Control subject, to acquire mastery of operating, troubleshooting and problem solving and to develop design and technical skills.

Throughout the Workshop studies the students prepare individual projects aimed at improving the existing systems or designing new systems for various applications. The students' creativity in the projects is encouraged.

4. Experience and evaluation

Machine Control discipline is taught in more than 150 high schools, that is about 20% of the high schools in Israel. Implementing Machine Control as part of school reform caused several major changes in technology and general education.

The number of students who studied technology at the matriculation level (three and five points) increased from about 7% in 1990 to about 30% in 1999. The number of graduates who decided to continue technology studies in technical colleges has increased by 65%

since 1995. The number of technical colleges in mechanical engineering has increased significantly. Professional qualifications demanded from technology teachers were re-defined in 1994, so that an academic degree in engineering is required.

The discipline was developed primarily for vocational and comprehensive schools (for technology majors). In 1993 the discipline got accreditation by the Israeli universities as one of the preferred matriculation subjects. As a result it became attractive also for general secondary schools which are a most prestigious part of secondary education in Israel. The number of general secondary schools participating in the initiative increases annually and is currently fifteen.

All these schools are known as top-level schools. The participants are students studying math and physics at the advanced level. They choose the discipline because of its intellectual challenges as well as bonuses given by the universities. Many of these students select an opportunity of alternative graduation assessment given by the Ministry of Education. Accordingly, the student prepares and submits an individual extended graduation project as a substitute for the regular matriculation exams in the discipline. The features and educational evaluation of this program are presented in (Verner et al, 1997,1999).

Since the 1998-99 school year the students have participated in a local robot contest in Israel and in the Trinity College Fire Fighting Robot Contest in Hartford, U.S.A. Participants in the contest are university students as well as hobbyists and high school students studying advanced technology and science courses. The common task for all teams is to build a robot that can move through a model of a single floor house, detect fire and extinguish it (Ahlgren and Mendelssohn, 1998). The Israel delegation at the Fire Fighting '99 contest included 24 students from five schools.

5. Conclusions

This paper presents Machine Control – a design and technology discipline that has been developed in Israel to meet the goals and follow the trends of modern technology education. The discipline has been widely implemented in high schools and got the status of an optional matriculation subject.

The discipline curriculum is designed to provide the significant intellectual challenge for different learning populations, including students of comprehensive, general and vocational schools, higher and lower achievers.

The Israeli universities, industries and army recognize the value of knowledge and skills acquired by the students through the Machine Control studies at high school.

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Nadav Betzer is a National Inspector for the Study of Mechanics in High Schools and Technical Colleges, Science and Technology Administration, Israel Ministry of Education. He is also an adjunct teaching associate at the Department of Education in Technology & Science, Technion. N. Betzer was a chief engineer at the Ambar Ltd. central feedmill (1976-1985) and a teacher of mathematics, technology and physics in high schools (1985-1990). His interests are in engineering and technology education, integrated curricula, machine control and mechatronics. He graduated from the Ruppin technical college, Department of Mechanical Engineering (1970), received a B.Sc. degree in Agricultural Engineering from the Technion (1981) and a M.A. degree in Education from the Tel Aviv University (1991), Israel.

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