A Robotic Chemical Analyzer

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Abstract. *Educational robotics seems to be an important field for the development of the energetic attendance and self-activity of students. The combination of software development with the mechanic construction gives an opportunity to connect the robotics with science applications. The direct connection of science applications with robotics opens a dialogue's window of the students, with cross-thematic approaches, and groupwork applications. The present work, tries a connection between applied chemistry with robotics. It includes the construction of a robotic chemical analyzer (titrator), able to measure automatically, a chemical parameter in a group of samples. The upgradability of the construction, gives an opportunity of a continuous improvement. This improvement, of the software, the automatism, the variety of applications, the technical characteristics and the additional construction of support units, maintains a diachronic interest of the students for the robotic chemical analyzer.*

Keywords. Educational robotics, Science teaching, Self made apparatuses.

1. Introduction

Educational robotics [1] seems to be an appreciable area for the growth of self-activity, spontaneous energetic attendance of students and groupwork study. The majority of the students are familiar with computers. It allows us to focus all our effort in the organization of the construction through a well determined project. This project starts from the point "what I want to manufacture", it then examines ways that given software may be used to serve the needs of the construction, continues with the description of the technical materialization of the construction, and is completed with the matching of the hardware with the software to have the required result.

This is a multilevel planning which, combined with the fact that the majority of educational robotics is a team work, will result that the particular action from each member of team, begins as individual action but is fulfilled through the team, and produces a collective result, in which the autonomy of the individual action is obvious. The personal inspiration and the individual planning should be presented in an appropriate form in order to be negotiable with the team. A project like this includes all the important elements of self-activity of energetic attendance of groupwork study, imposing an essential internal treatment for each member of the team [2]. For the schoolteacher of natural sciences, it appears that initially, educational robotics can be a carrier of all desirable training attributes that we would appreciate to be available in natural science students [3] [4].

Hence, the challenge for a connection of educational robotics with the natural sciences is present. For a robotic application of a creative game type, that is comprehensible from the student, it translates to "what should I do". The construction in educational robotics based on the science application does not cause itself the interest but it is stimulated by the usefulness of application and the challenge to manufacture "exotic" robotics appliances of trade. The sense of control of the total construction, as well as each of its individual department, the analysis of total in the parts and the composition of total from the parts, are an unusual experience for the students. From the side of science such a construction requires a interdisciplinary approach of the application, which meets a fertile ground as science is not end in itself, but is used in order to it attributes to us a measurable and useful result. We believe therefore that the enlargement of application of the educational robotics in spaces of utilitarian applications of the science opens a new field of experimental applications.

2. Methodology.

A project for the materialization of the above mentioned didactic proposal is the construction of a robotic chemical analyzer according to the following methodology.

A common measurement method in the chemistry is the titration. Titration is a method in which a known volume of an unknown concentration solution reacts with known concentration reaction agent. The end of reaction becomes obvious with a variety of ways, usually with chromatic change. Follows calculation, for the determination of the unknown concentration. On the manual method of titration, we use a probe for the progressive addition of the reagent up to the chromatic change. The above process can be automated with a robotic construction. A typical application, which can constitute the initial challenge for the students, for such analyzer, it is the measurement of acids in the wine. The application for the students will start from an initial search for the wine and its history, the factors affecting the tasty and smell characteristics of the wine and the importance of acids for these characteristics. What type of acids exists in the wine, how these are associated with the local and weather particularities how we measure their quantity. Follows a short laboratorial experience of acids measurement manually with the use of a probe, reagent of sodium hydroxide and phenolphthalein as an indicator.

The experience that will be acquired constitutes the needed spark for the construction of a robotic chemical analyzer.

3. The Application.

In this particular project, we used the system Mindstorm of LEGO. It was an effort to construct the titrator with the parts of one single set.

The construction is based on logic of substitution of human manual work by the robot. The system is constituted by the following departments (see **Figure 1**).

1. Sampler: It is circular sample carrier. For its construction, they have been used parts from a common home blender. The sample carrier has at the first place the blank sample, at the second the standard following by the unknown samples. A step motor, controlled by the computer unit, moves the carrier to the proportional sample.

2. Syringe for the Reagent's Volume Measurement: It is a common syringe, the piston of which is connected with a screw, controlled by step motor of LEGO. In each complete rotation of the motor, the piston moves at an equal to the step of the screw distance. This corresponds in a concrete reagent volume that is added and the computer in each measurement enumerates the number of turns of the motor that was spent up to the end of reaction.

3. The Valve: The syringe after each measurement will be supposed to fill with reagent for the next measurement. This become through a 2-way valve, which is controlled by a step motor via the computer. In the first position, it adds the reagent for the measurement and in the second it reabsorbs the used reagent, in order to be ready for the next measurement.

4. Optical Detector: The optical color detector determines the end of the reaction (equivalent point) from the change of color.

5. Magnetic stirrer:

It is independent exterior unit which stirs the sample during of reaction time.

6. Unit of computer: In this unit are connected the motors and the detector. Also it is loaded and executed the software.

7. Software: The structure of the program.

Figure 1

The first sample is blank; it contains all reagents and water instead of sample. Reagent is added until the detector realizes change of color. The turns of the syringe motor are measured. The valve changes position reabsorbs the spent reagent that it had been add in the measurement. The valve comes back in the position of reagent's addition. The motor of the sampler moves the second sample for measurement, which is the standard (known concentration sample). The number of syringe motor turns are measured as already described. The sampler motor moves to the first unknown sample. Number of turns are measured as already has described.

For the calculation of the unknown concentration, we use the formula:

$$CS=(RS-RB)CST/RST-RB$$ where:

Cs: the concentration of the unknown sample
RS: the number of turns of the syringe motor at the measurement of the unknown sample
RB: the number of turns of the syringe motor at the measurement of blank sample
CST: the concentration of standard sample
RST: the number of turns of the syringe motor at the measurement of standard.

According to the above calculation the system gives the result. It continues with the next samples.

4. Upgradability

The upgradability of the system concerns the software, the hardware and the applications. The upgradability gives in this project a diachronic development and a continuous improvement. Each extension, acts also as a critical regard of already existing system,

4.1. Program upgradability

The upgradability of the program, concerns important points of his structure, which influence the faculty of system to be friendly in the user, to be able to invite new applications, to optimize the conditions of speed and effectiveness, to avoid interruptions of the operation caused by program's weaknesses.

4.2. Applications upgradability

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The system with suitable changes of the reagent, the program, and probably with the use of auxiliary systems, could extend its operation, in other interesting applications. Such an application is the measurement of acids in the olive oil, which has some additional difficulties on the sample treatment.

4.3. Hardware upgradability

We constructed the parts of the system, by using common materials, without special laboratory equipment, constitute a source of inspiration for the students is a challenge to improve and to supplement their constructions as individual units, as well as for the composition of new appliances in combination with additional ideas. This is the objective of such an application, to have the student a challenge of autonomous interest in science. For example, we can in order to upgrade the system, to add one unit for the preparation of the sample, which adds a second reagent, phenolphthalein or the dilution reagent for the measurement for the olive oil.

5. Connection with other sciences.

This type of applications, are able to connect directly a number of sciences. Local tradition that concern special care for the production of qualitative foods, for example wine, olive oil, and the connection of their quality with measurable chemical parameters. Students can study also hoe the collection time, the morphology of the area, and the illnesses of the plants that affect the quality of the foods. It can be connected with nutritional value of the food. However the most important connection is with the mathematics. The significances of precision, reputability and resolution of the measurements are clearly statistical significances. The calculation of the concentrations use mathematic formula, via which, we can comprehend the significance of measurement's unit and its use. On the other hand, the use of a pHmetric detector constitutes an important application for Lyceum students, because the calculation of equivalent point requires the use of derivatives on the curve of pH- volume of reagent.

6. Epilogue

Our laboratory has already a long experience on the application of self-made experimental apparatuses using simple materials, focusing especially on polymorphic [6] quantitative measurements [7]. We have also an equivalent experience on the educational robotics [8], [9]. With the proposed type of robotics application, we effort on the combination of our two fields of activity. A limited initial application on the students our laboratory and science teachers of secondary education shows that exists an important interest. A future extension of our applications will allow us to enounce more intergrated conclusions.

7. References (and Notes)

[1] Robot means any (mechanical) device capable of performing (pre-programmed) physical tasks (e.g. moving, controlling other devices, reacting to changes in their environment, etc.) and may be considered as

the evolution of automata. Robots may be controlled by a human (for example the different kind of probes used in the exploration of earth or space and in surgery) or be controlled by appropriately programmed computers separate from (or being part of) the robot construction. Although the popular notion of robots relates to humanoids (former term used androids), robots may have any form appropriate for the task they were constructed for. The word robot (originating from robotovat meaning to work, to serve) appeared for the first time in the play RUR (Rossum's Universal Robots) by the Czech Karel Čapek in 1920 to describe humanlike creatures obeying a master. They are now very popular in (science) fiction.

[2] The goal of constructionism is "giving children good things to do so that they can learn by doing much better than they could before (Papert, S. (1980). Mindstorms: Children, Computers, and Powerful Ideas. NY, New York: Basic Books.)." Is a natural extension of constructivism and emphasizes the hands-on aspect. Papert discovers ways in which technology enables children to actively use knowledge they have acquired.

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[6] Polymorphic teaching in Science and Technology includes a common psychomotive activity (e.g. constructions, measurements, experimentation ...) which consequently is morphed into different education levels depending on the (previous) cognitive attainment and/or the mentality of the students. It resembles multilevel teaching (i.e. teaching pursuing more than one sectors and levels of learning). The need for polymorphic practice teaching arises usually in the training of teachers to the subjects they are going to teach in school where there is a requirement of teaching in an advanced level for the teachers themselves and teaching in a level more accessible for the pupils. See more in P. G. Michaelides, "Polymorphic Practice in Science", pp 399-405 of the proceedings of the 1st Pan-Hellenic Conference on the Didactics of Science and the introduction of New Technologies in Education, University of Thessaloniki, Thessaloniki May 29-31, 1998 (in Greek).

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