Introducing the radio frequency identification technology to a vocational high school programme in mechatronics

F. Vrbančič† & S. Kocijancic‡

High School of Electrical Engineering and Computing, Ptuj, Slovenia†
University of Ljubljana, Ljubljana, Slovenia‡

ABSTRACT: Radio-frequency identification (RFID) is a technology, which uses radio waves for automatic identification. The paper presents an introduction of RFID technology to educational curricula. In Slovenia, the reformed educational programme for high-school mechatronics technicians was introduced a couple of years ago. The first part of the paper focuses on teachers facing the challenge of how to transfer the knowledge that should be used in a creative way in new and unexpected situations. To achieve such an aim, teaching methods should include contemporary topics, which support the best possible quality and sustainability of knowledge and skills. The paper outlines radio frequency identification technology topics. Integration possibilities of such global technology into the practical and theoretical part of the technical and vocational educational programme are also presented. The core part of the article is a case study of integration of RFID topics into the educational process of the second year of the reformed mechatronics programme. The possibility of introducing RFID technology adapted to a small group of gifted students is also outlined.

INTRODUCTION

In Slovenia, reformed programmes of vocational and technical education were introduced in 2005. At the same time, the new secondary school educational programme in mechatronics technology was implemented [1]. The innovations through the reforms were:

- Education with clear aims and project based learning - professional competence or, in other words, what the students have to achieve at the end of each school subject as defined in the educational catalogue. Previously, no topics and methods had been mentioned, and they were matters for the school or were chosen by the teacher.
- Compulsory interdisciplinary connections between professional and general topics in the education curriculum.
- Implementation of 400 hours of *open curriculum*, in which local social partners can influence the educational process, and help to realise local and regional educational aims and needs.
- Reaching general competence levels - teamwork, learning and foreign language usage, ICT learning and usage, adopting the lifelong learning philosophy, etc.

It is no less important that the teachers and the school have to:

- ensure the optimal condition of development to each student;
- establish special programmes and methods of working with gifted students;
- establish special programmes and methods of working with students of limited abilities.

It is, therefore, clear that teachers are facing the challenge of implementing the key elements of reforms in the educational process. Even more, there had been no restrictions before the reform about implementing the innovations, but only a few teachers really did it.

A common thought that arose from the analysis of described needs was the implementation of project-oriented work to meet the demands. However, which project (case study problem) should be chosen was the question.

In the process of project selection, the teachers in the School of Electrical Engineering and Computing at Ptuj had some additional limitations:

- financial resources for materials and didactic tools purchasing were very limited;
- teachers were not used to interdisciplinary work;
- some teachers did not follow the innovations in their own professional field,

- most teachers' experience of the reform was as extra work, and they did not accept additional work to change the working methods and topics used so far;
- companies had high expectations about students' knowledge and work skills with new and current technologies, as well as with the standard ones.

The literature proves that project-oriented work attracts and interests individuals [2-7].

By considering all demands and limitations, the following topics were selected: RFID technology and its problems, programming intelligent mobile phones (system android), Cloud Systems-Architecture and Computing, USB technology and TCP/IP technology.

Why RFID Technology?

RFID technology was chosen because:

- It captures the most problems.
- It is contemporary, and it is used in many products.
- It is context related to bar code identification.
- It enables work with students of different levels (gifted students, others).
- It enables team and individual work.
- Documentation of software and hardware is free, available and updated.
- It enables the interdisciplinary work connection between general subjects and professional ones.
- RFID technology can be matched to many topics, which have been still in use, such as programming, basics of electrical engineering, computing, microprocessing, linear and discrete elements etc.

Relevance of an issue was of rather high importance, so we checked with 40 companies in the region through questionnaires, to rank the mentioned technologies. Thirty-two companies responded and most of them shared the opinion that RFID knowledge issues could be used. Some companies suggested other technologies, mostly because of the specifics of their work.

Short Description of RFID

RFID is the general term for technology that uses radio waves for object, people or data automatic identification. The mass usage of RFID technology has been limited by the high price of such systems, but the problem of the price is becoming a side issue. Nowadays, RFID systems are available at a fair price, and that is one of the reasons for the usage of RFID support information solutions in a wide range of sectors and activities [8][9].

RFID tags include a chip that typically stores a static number (an ID) and an antenna that enables the chip to transmit the stored number to a reader. The RFID reader (receiver) produces a continuous electromagnetic (EM) energy flow into its surrounding area. When the RDIF tag (transponder) enters the EM field, the tag's coil induces power from it, which starts transmission of RDIF data by modulating an EM field (see Figure 1).

Modulated signals are demodulated - directed and with the low-pass filter cut out the useful information directed to the input of the comparator. On the output of comparator, the digital form of the useful information is shown and it is fed into the microprocessor.

To complete the RFID reader design, a fast microprocessor is needed in order to translate the encoded data that streams from the tag device, and to format the data appropriately and transmit it to a personal computer for next stage of process, if necessary, and the memorisation [10-16].

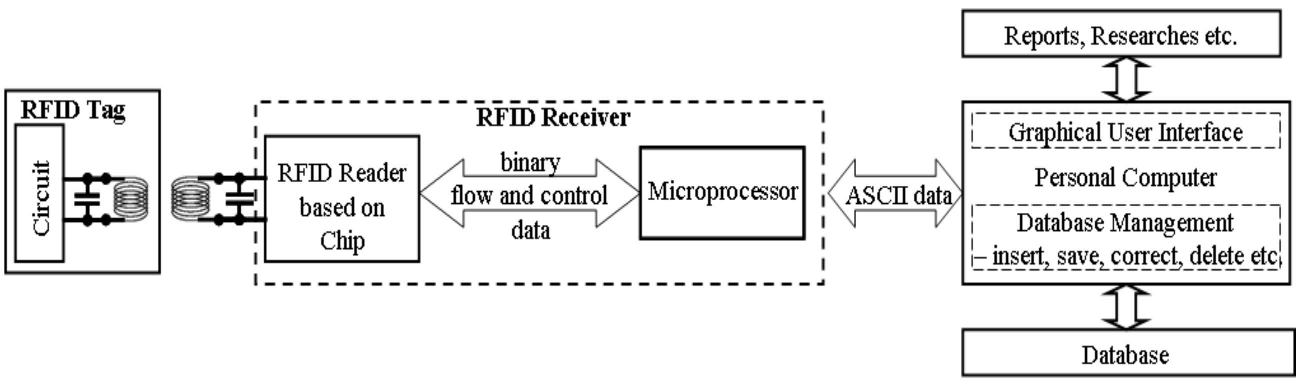

Figure 1: Block diagram of RFID system.

RFID TECHNOLOGY IMPLEMENTATION INTO THE EDUCATIONAL PROCESS

The work was set as the nine-month project. Eight teachers of different subjects were involved: programming, mechatronics, practical work, Slovenian language, English and mathematics.

In the nine-month period, the students had to plan, make their own hardware and programme the firmware RFID receiver. They had to make their own graphical user interface on their PC and to manage the data (reading, saving, analysing, computing data). The product was developed according to the top down method - the final product was presented to the students first, continued by studies of its functionality, its performance improved with the help of the basic electronic elements.

Thirty-one students in the second school year of the Mechatronics Programme in the School of Electrical Engineering and Computing (one class, 16 year-old students) were involved. The class belonged to the fourth generation of mechatronics at the school and to the first generation to be educated using the problem-oriented method. It was the only mechatronics class in this generation. Having a comparative group of the same generation was not possible, because of the aforementioned reasons. However, the data obtained were compared with data from the previous generation.

Issues were presented in three phases, each phase lasting three months. Because the educational programme involves two semesters, the evaluation was modified. The first phase and part of second phase were evaluated in the first semester, the rest of the second part and third part were evaluated in the second semester. Part of the evaluation involved the students' and teachers` satisfaction.

Monitoring and evaluation were in progress in two school professional subjects - Mechatronics and Programming and two general school subjects - Slovenian and English. These school subjects were chosen because they involve issues for the final matriculation examination (known as *Matura*).

First Phase

An RFID receiver in the form of a USB HID (Human interface device) was given to the students. The RFID receiver was a black box, which returned a sequence of ASCII signs in the output, when the RFID tag was close to the input (Figure 2).

In programming, the students had to plan and perform the graphical user interface and the simple management of RFID ASCII sequences (saving, analysing, copying-printing). Issues of introducing basic programming commands (loops, assignment, conditions and variables, working with input and output consoles), planning and encoding of simple programmes were considered in the work. Software such as Delphi, Visual Basic and Visual C++ were used (Figure 3).

Figure 2: USB RFID receiver.

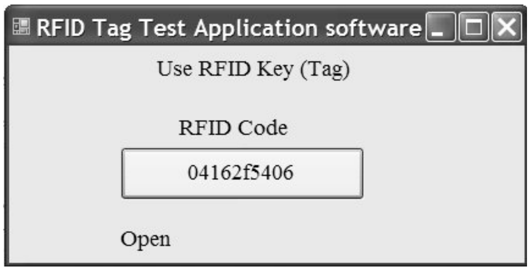

Figure 3: Graphical user interface.

In mechatronics school subjects and practical work, the students learned how to use measurement devices, such as voltmeters and oscilloscopes. They measured and controlled the signals in the output of the RFID transmitter. They learned about the basic elements of the feeder (resistance, capacitor, integrated circuits, rectifier circuits), made the feeder, and used it for the RFID circuit feeding. They also learned about the usage of the basic technical laws relating to electricity, such as Ohm`s Law, and Kirchoff' s Current and Voltage Laws.

In Slovenian and English, they learned the professional terminology, and they had to prepare written and oral reports about the work. Information was taken from a range of literature sources.

In this phase, the possibility of extra interdisciplinary connections with other school subjects in computing programming was shown. Students could plan and perform database management and more complex user interface for data manipulation (storage, safety etc).

Second Phase

The RFID receiver was split into the RFID reader and decoder. The RFID was a black box, which returned a sequence of binary signals (5 V and 0 V) in the output, when the tag was shown in the input.

The students had to decode the signal with the help of a microprocessor, which transforms the binary frequency of RFID reader into an ASCII sign sequence. They had to choose the microprocessor, write the firmware and get the product to work. They learned about the software for structural programming. The students recognised the differences between analogue and digital signals, the terms frequency and period, and the process of planning and progress of product prototypes.

Third Phase

The students had to build an RFID reader with the help of chips and basic electronic components.

In professional subjects, the students learned about connections between basic electronic elements into circuits. They understood about circuit activity and the influence of the individual components on the circuits, such as comparators, LC, RC and quarts oscilloscopes, electrical filters, etc. They learned about the information coding and encoding methods, procedures and media of signal transfer, USB and TCP/IP technology standards. They used a range of literature and catalogues. They had to prepare full documentation for the product, the process of product production and make an oral presentation of the product (Figure 4).

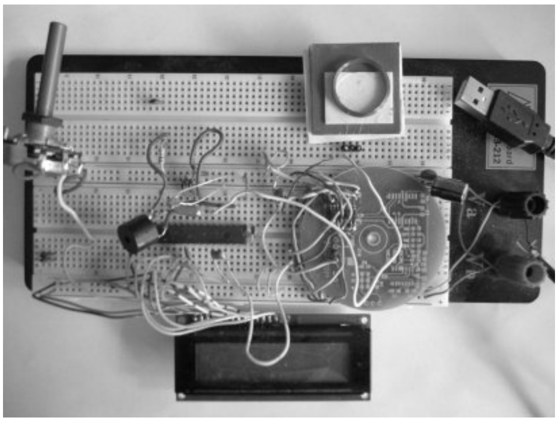

Figure 4: Prototype of RFID receiver.

RESULTS

Evaluation and Assessment of the Students' Work

The students` knowledge was assessed at the end of the first and third phases. The students` satisfaction was evaluated at the beginning of the first phase and at the end of the third phase. The teachers` satisfaction was evaluated at the end of the third phase.

Each educational period was based on the minimum of gained knowledge, which should be adopted by the student. The basis of the knowledge was school and the national learning syllabus. At the end of the testing period, the knowledge was measured through a test.

It included 55% of the tasks referred to the knowledge minimum - knowledge reproduction. Each test was evaluated according to criteria determined by two assessors. In cases where the grade differed by more than 5%, the test was evaluated again by a group of three teachers. The criteria were: 0% to 39% - insufficient, 40% to 50% - sufficient, 56% to 70% - good, 71% to 85% - very good and 86 % to 100% - excellent.

Student and teacher satisfaction was estimated through interviews, on a scale from 1 (very unsatisfied) to 10 (very satisfied).

First Phase Evaluation

The students` knowledge was evaluated with a knowledge test at the end of the first semester. Results are shown in Figure 5.

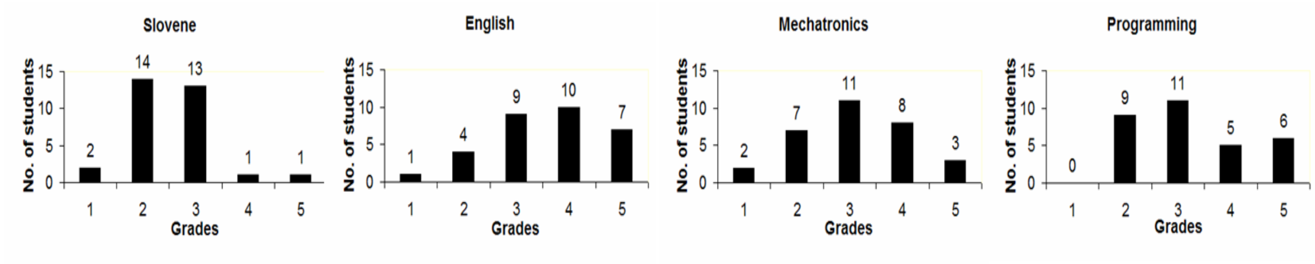

Figure 5: Distribution of assessments.

Second Phase Evaluation

We did not evaluate this phase; the students' work was mostly monitored and checked. A part of this phase was evaluated in the first semester, together with the first phase; the other part was evaluated at the end of second semester, joined with the third phase.

Third Phase Evaluation

The students' knowledge was evaluated on the basis of product documentation, oral presentation of the product production process and presentation of the working product. An oral examination was held in front of the board of examiners - teachers of the school subjects involved in the project. The satisfaction evaluation of students and teachers was performed at the end of the project. The results are shown in Figure 6.

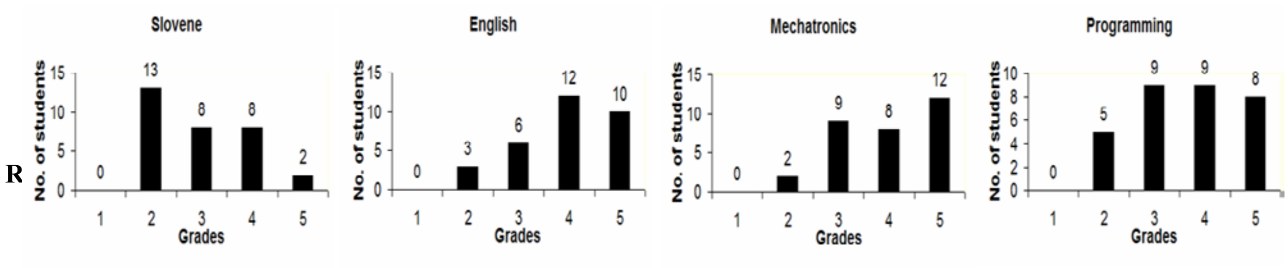

Figure 6: Distribution of assessments.

Students` Knowledge

There were no unsuccessful students during the school year. On average, the grades in second semester increased by one level over the first semester. The differences in grades in new methods of transferring knowledge were not significant, but there was a big difference in students` and teachers` satisfaction.

Students` Satisfaction

In the first phase, the students evaluated their satisfaction according to the educational process in the first school year. The students graded their satisfaction with new methods at two levels higher than it had been compared with the education in the *traditional/old* way (each school subject separately, no problem-oriented educational methods, etc). The students` satisfaction was measured via a questionnaire with questions scaled from 1-10. The students' satisfaction in the first and third phases is shown in Figure 7. The higher the grade, the more satisfied the participating students were. The lowest grade in the first phase was 3 (mostly not satisfied), the highest 8 (satisfied) and average 5.5. The lowest grade in the third phase was 6 (satisfied), the highest 10 (totally satisfied) and the average 8.5.

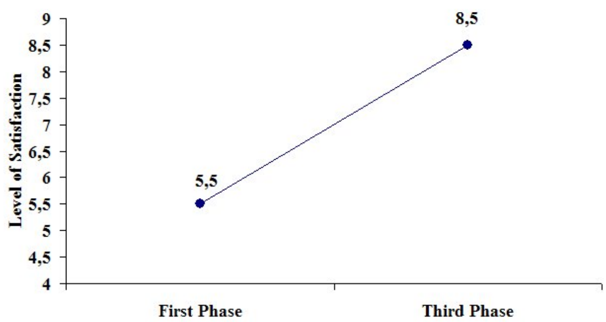

Figure 7: Satisfaction of students.

Students' interest increased - some students gained ideas for the fourth part of the final examination, which is the final stage of completing the educational process and it is obligatory.

The students were exposed to interesting issues and the connection between different subjects for the same purpose - one project, one task, one report and they get the grades in more subjects. The flow of knowledge transfer between different school subjects was very natural (for example, between mathematics, English and professional subjects). In the *old/traditional* way, such connections were not present, because each school subject was an individual unit.

Students' independence increased significantly. In time, students could get the information by themselves. Gifted students suggested the issues for the research work themselves. The students were warned that they should take care of their own personal and professional development constantly.

Teachers' Satisfaction

The teachers were more satisfied with the new teaching methods, even though such methods required more planning and team work. However, they noticed that students were more prepared and motivated in the lessons.

Teaching issues could stay the same, only the method and the transfer of knowledge changed. The innovation was the implementation of learned issues into the problem-oriented work.

Teachers' satisfaction was measured with the questionnaire and questions scaled from 1-10 (1 - not satisfied, 10 - totally satisfied). The lowest grade was 7, the highest 10 and the average 8.

CONCLUSION

Reform required new approaches in education. Most people usually rebel against changes, but new issues of new technologies combined with problem study lessons is one of the ways to change educational process into something higher.

However, changes bring advantages and disadvantages. One disadvantage is the lack of funding. Even with relatively cheap material, it was not possible to ensure that all students would have the material at home. The second disadvantage was that some teachers were not prepared to modernise the issues and the methods of their work they had been using in the past.

The advantages of such education are many: higher motivation of students, their satisfaction, independence, challenge as the part of learning process and not the need. Very important is the integration of the knowledge from different fields joined into one whole. Even though the approach is united, it enables individuality, if there is a need and desire. Such an approach provides the opportunity for personal and professional growth of interested students and teachers.

According to the experience, such an approach encourages the usage of modern communication tools, obtaining and evaluating the gained information, lifelong learning, the importance of foreign language learning, etc, and all these lead to the context of a learning society.

REFERENCES

1. Ministry of Education and Sport of Slovenia, Law of the education organisation and financing, ZOFVI- UPB1, 14, (2005).
2. Kocijancic, S., Kušar, T. and Rihtaršič, D., Introducing programming languages through data acquisition examples. *Inter. J. Eemerg. Technol. Learning*, 3, **2**, 28-33 (2008).
3. Rihtaršič, D., Šantej, G. and Kocijancic, S., Promoting engineering studies through summer camps of electronics and robotics, *Proc. 2nd WIETE Annual Conf. on Engng. and Technol. Educ.*, Pattaya, Thailand, 64-69 (2011).
4 Adelson, B., Issues in scientific creativity: insight, perseverance and personal technique. *J. of the Franklin Institute*, 163-189 (2003).
5. Craig, L., A Guide to Increased Creativity in Research - Inspiration or Perspiration? Bioscience: Research Library Core, 40, **2**, 123 (1990).
6. Juriševič, M., Creativity in the Zone of Proximal Motivational Development, Facilitating Effective Student Learning through Teacher Research and Innovation, University of Ljubljana, Faculty of Education, 415-429 (2010).
7. Vigotski, L.S., *Mišljene in Govor, Ljubljana.* Translated from Preface: Gaber, S. and Marjanovič, Umek, L., *Myšlenie i Reč*. University of Ljubljana, Faculty of Education, 245-254 (2010) (in Slovenian).
8. Floerkemeier, C. and Lampe, M., Issues with RFID Usage in Ubiquitous Computing Applications. Zurich, Institute for Pervasive Computing (2004).

9. Ng, M.L., Leong, K.S., Hall, D.M. and Cole, P.H., A small passive UHF RFID tag for livestock identification. *IEEE Inter. Symp.*, Melbourne, Austaralia, 1, 67-70 (2005).
10. Microelectronic, RFID Made Easy, EM Microelectronic - Marin SA (2002).
11. Vogt, H., Efficient object identification with passive RFID tags. In: Mattern, F. and Naghshineh, M. (Eds), *Proc. Inter. Conf. on Pervasive Computing*, Lecture Notes in Computer Science, Zurich, Springer-Verlag, 2414, 98-113 (2002).
12. Accardi, R., EM4100 Protocol Description. Melbourne: Priority One Design (2007).
13. Microelectronic, Read Only Contactless Identification Device, EM Microelectronic - Marin SA (2005).
14. Colnarič, M, Verber , D. and Halang, W.A., *Distributed Embedded Control Systems - Improving Dependability with Coherent Design*. Berlin: Springer Verlag, 132-163 (2008).
15. Ranasinghe, D.C., Leong, K.S., Ng, M.L., Engels, D.W. and Cole, P.H., A distributed architecture for a ubiquitous RFID sensing network. *IEEE Inter. Symp.*, Melbourne, Australia (2005).
16. Seshagiri Rao, K.V., Nikitin, P.V. and Lam, S.F., Antenna design for UHF RFID tags: A review and a practical application. *IEEE Transactions on Antennas and Propagation*, 53, **12** (2005).