SKILLS4WORK

VET & BUSINESS PARTNERSHIP

CASE STUDY | Slovenia

An example of execution of the project week from the area of Mechatronics based on the topic of 'Electric Bicycle'.

INTRODUCTION

How to motivate students in the process of education to become active to their maximum, and how to place them in a situation where they can develop their innovativeness, responsibility, creativity, interactivity, the ability to connect theory with practical work and to perform publicly, ...?

BACKGROUND

The last reform of secondary vocational and technical education aimed at the following: promoting the predominance of goal-based learning and problem-planned lessons in educational process, the connection between general and technical knowledge, teaching theory alongside practical work, and establishing the basis for innovative methods of teaching and learning. At the same time we want to encourage maximum activity and responsibility among the students, their personal development, which means their professional and key competences.

The above mentioned goals form a basis for a different, i.e. problem-oriented lessons with a teaching method called project days or a project week.

The gist of a Pproject eek is that all the teaching is focused on one chosen topic. It encourages creative and critical thinking, and enables a wholesome view on the problem. The students need such education that gives them a general overview of science and at the same time ensures the durability of their knowledge, which proved as a positive side of project work.

CHALLENGES

The Project Week concept is a characteristic example of a problem-oriented teaching, i.e. student focused teaching. The students co-operate to solve problems and gain new knowledge, work on problems in small groups and are mainly responsible for the work. The teacher acts as a mentor and directs their work. The students organize all their work in their group while the teacher provides all the necessary support.

Obviously, there is always a problem of what kind of an example from real life to choose so that the task will still be interesting and, at the same time, not too challenging for their level of knowledge. There is also an organizational challenge, namely, how to carry out the project week for all the classes and teachers at the same time. Certain lessons have to take place in specialized classrooms with enough computers for the students to do their work. The companies which the students visited or whose representatives visited school to pass their professional knowledge to students also had to be contacted and invited.

SOLUTION

The above mentioned method has been tested at SC Kranj in the second year's Technician of Mechatronics and Mechatronic Operator programmes. The topic of the project week was Electric drive bicycle. Why this topic?

We are all familiar with a traditional bicycle but the electric drive bicycle is only just gaining ground. It is not so familiar to students so it presents a challenge – an unexplored area. So it is not a coincidence that we chose electric drive bicycle for the topic of the project week. We divided the main topic into 8 sectors, which were chosen according to the amount of interest and also enabled us to execute interdisciplinary teaching. The sectors were the following: Cycling, Bicycle Construction, Materials, Mechanical Transfer of Power, Electric Drives, Resistance and Loss, Sources of Voltage (locations, standard switches), Testing and Reversibility (charging when driving downhill).

Since we have good contacts with the General Representative of Electric drive bicycles for Slovenia, we could borrow one of their latest bicycles for testing and research. There were no problems with written specifications as the material was delivered together with the bicycle. We also invited their repairman to visit us at our school. The students were divided into 8 groups, taking special care of balancing the group according to their abilities and educational programme (STE ansd SVE, Secondary Technical and Secondary Vocational Education). Each group researched one of the above mentioned sectors.

The students also visited the Motorcycle Museum and the Safe Driving Centre in Vransko where they learnt about safe driving as they are going to be young drivers in a couple of years while the majority of them are already enthusiastic cyclists.

Macro preparation

Subject	Project week, Mechatronics
Programme	Tehnician of Mechatronics, Mechatronic Operator
Year	2nd year of Secondary Technical Education (2.Ma, 2.Mb) 2nd year of Secondary Vocational Education (2.Me)

- TIME OF EXECUTION: April 2014
- PLACE: SC Kranj – Secondary Technical School
  - Safe driving Centre Vransko
  - Vransko Motorcycle Museum
- OBJECTIVES: development of divergent thinking in students, creativity and gaining, strengthening, deepening and use of knowledge from the field of engineering, technology, work organization, economics, ergonomics, ecology, information technology, computer science, industrial design, etc.
- PROGRAMME/TOPIC: ELECTRIC DRIVE BICYCLE
- LEADERS mentors: 8 mentors for 8 groups
- NUMBER OF PARTICIPANTS: 62
- STRUDENTS' TASKS: according to the topics of individual groups:
  - to find electric and mechanical elements at mechatronic systems of an electric bicycle,
  - to study an actual mechatronic system from the point of view of functioning,
  - to get familiar with technical documentation,
  - to learn about safety and quality standards,
  - to get familiar with the history of invention and development of vehicles,
  - to study the meaning and role of individual mechatronic components in the system,
  - to establish the impact of vehicle production, their use and used vehicles on the environment,
  - to learn about the meaning of recycling or use of disused vehicles for other purposes,
  - to communicate in their mother tongue and foreign languages,
  - to be able to speak publicly with self-confidence,
  - to use ICT,
  - to find different information sources, separate what is important, and pass it on,
  - to behave appropriately and politely,
  - to react with tolerance and in accordance with etiquette,
  - to work independently and reliably,
  - to successfully co-operate in a team.
- ESTIMATED NUMBER OF HOURS: 33
- EQUIPMENT: electric drive bicycle, computers, technical literature, written materials, catalogues and technical specifications of the bicycle.
- STUDENT REQUIREMENTS: the material is provided by the mentors according to the topic of the group, they have access to ICT (the Internet).
- COSTS: the costs of the technical field trip.
- METHODS AND CRITERIA OF EVALUATION/ASSESSMENT:
  - the methods and criteria are defined in a detailed execution plan of the project week,
  - evaluation will be carried out on the level of students, teachers and organization of the project.
- AN IDEA FOR PRESENTATION AT PRESENTATIONS' DAY:
  - presentation of the Project Week for parents, students and teachers in the great lecture hall,
  - presentation on the school website.

Micro plan

1st day	Assembly of all the participants of the project week in classroom 274 –presentation of the project week - introduction Classrooms required: 275, 278, 282, 274 (253, 341, 284, 347) forming groups of students with their mentors and classrooms; group work
2nd day	Assembly of all the participants of the project week in the car park in front of the school field trip - a visit to Safe Driving Centre in Vransko - a visit to Celje and their Regional Museum
3rd day	Assembly of all the participants of the project week in classroom 274 – a meeting and talk with a bicycle repairman, Mr Matjaž Bogataj; group work and preparation of the presentation
4th day	Group work as arranged by the mentor; preparation of the presentation
5th day	Group work as arranged by the mentor; preparation for the presentation rehearsal for the presentation of the project week; presentation of the project week for the students, parents, teachers and invited guests in the school lecture hall.

Mentors have been selected for the students to direct and help them with their research work as well as co-mentors from teachers of other subjects to provide additional help.

The students were divided into groups while paying special attention to the balanced and mixed ability of each group (STE, SVE):

1st group Cycling	*2nd group* Bicycle Construction	*3rd group* Materials	*4th group* Mechanical Transfer of Power
mentor:	mentor:	mentor:	mentor:

5th group Electric Drives	*6th group* Resistance and Loss	*7th group* Voltage Sources	*8th group* Testing and Reversibility
mentor:	mentor:	mentor:	mentor:

Project Realization

The project week was carried out in one week. The majority of research work was done by students in the mornings in school and some at home. One day was spent in the field trip to the Motorcycle Museum and the Safe Driving Centre in Vransko. The final presentation took place in the afternoon to make possible for the parents to attend it. The students were active all the time and so were their mentors who were always prepared to help them.

Each group chose their leader whose task was to present their work at the final presentation. The teacher first presented the topic of their task, technical literature obtained in the company and a sample electric drive bicycle. The students were able to take a ride with it, measure it, test it, in short, do whatever they needed for their research work inside their groups. They also took advantage of the Internet and a computer program for defining the centre of gravity and the load of the bicycle.

Group work


Vransko
Brode
Vransko
Čeplje
AMZS CVV
A1
LJUBLJANA
www.had.si

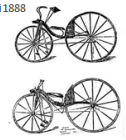
Impact and Outcomes

The students were asked to write a report on their findings and prepare a PowerPoint presentation. Among themselves they chose the presenters of their work at the final presentation.

Attachments – the results of group work

<table>
<tr><th colspan="3">1st group: Cycling</th></tr>
<tr>
<td>
Prvo kolo


Leta 1791 Francoz Comte de Sivrac izdelal prvo kolo
Leta 1816 baron Karl Drais bon Sauerbronn doda sedež
Škotski kovač, Kirkpatrick Macmillan l. 1839 doda pedala
James Starley-kolo Ariel 1870
Henry Lawson- verižni pogon 1874
John Boyd Dunlop-kolo s pnevmatikami 1888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<td>
RAZVOJ KOLESARSTVA

KOLESA JE NAJPREJ UPORABLJAL BOGATEJŠI SLOJ PREBIVALSTVA
KOLESA SO BILA ZELO DRAGA
KOLESA SO SI NEKATERI CELO ZAVAROVALI
ZA KRAJO KOLESA SO BILE VISOKE KAZNI
ŠIRJENJE MED VSE DRUŽBENE SLOJE
MNOŽIČNA UPORABA V REKREATIVNE IN ŠPORTNE NAMENE
USTANAVLJANJE KOLESARSKIH DRUŠTEV - TEKME
UPORABA V VOJSKI (1887 FRANCIJA), POŠTI (1892 JAPONSKA)




</td>
<td>
KOLESARSTVO NA SLOVENSKEM

Puhovo kolo

Sodobno električno kolo
</td>
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ZAČETKI KOLESARSTVA

V Ljubljani se je prvo kolo pojavilo leta 1869
Prvi kolesarji so bili bogatejši meščani (v Ljubljani, Kranju, Trstu, Mariboru, Celju in še kje)
Cena kolesa je bila približno 200-300 kron (štiri plače učitelja)
Težavo zaradi visokih cen koles so po svetu kot tudi pri nas reševali z izposojevalnicami koles
Konec 19. stoletja je kolo postalo pomembno prevozno sredstvo


</td>
<td>
PRVA KOLESARSKA DRUŠTVA TER TEKMOVANJA

Prvi kolesarski klub na Slovenskem so ustanovili Nemci leta 1885 (Der Laibacher Byciklisticher Club)
Slovenci so ustanovili svoj klub leta 1887 - Klub slovenskih biciklistov Ljubljana


Prvo dirko je Klub slovenskih biciklistov Ljubljana organiziral leta 1888 (4 km, zmagal je Kranjčan Peter Majdič)

</td>
<td>
Janez Puh- inovator

Leta 1889 je Janez Puh v Gradcu ustanovil delavnico, ki je že istega leta prerasla v tovarno
Že v prvem letu delovanja je izdelal okoli 100.000 koles
Kasneje se je Janez Puh začel ukvarjati z razvojem motorja in avtomobila
Puhov učenec je leta 1905 v Gorici ustanovil tovarno koles Tribuna, njena naslednica pa je bila nekdanja tovarna Rog


Rogovo kolo
</td>
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</table>

2nd group: **Bicycle Construction**

KONSTRUKCIJA KOLESA

VRSTE OKVIRJEV KOLESA

- Cestna

- Gorska

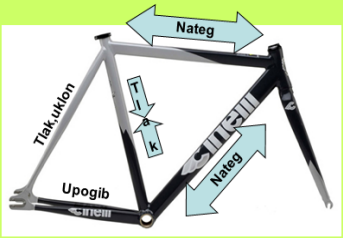
- BMX

DIMENZIJE OKVIRJEV

Dimenzija okvirja kolesa se loči po velikosti zgornje nosilne cevi:

- majhna (small): 400 mm
- srednja (medium): 440 mm
- velika (large): 490 mm
- zelo velika (extra large): 520 mm

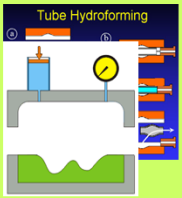
NAPETOSTI NA OKVIRJU

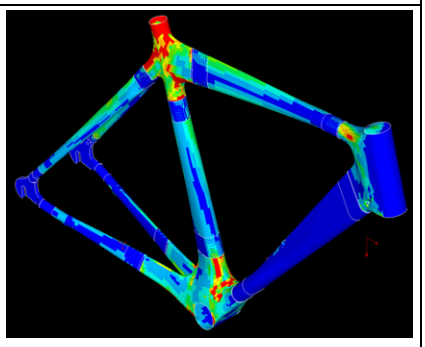


PROFILI CEVI

Poznamo več profilov za cevi kolesa:

- U - profil
- okrogle cevi
- kvadratne cevi
- hidroformirane cevi





3rd group: **Materials**

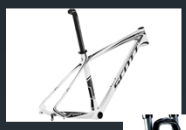
Materiali

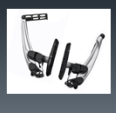
Materiali na vzorčnem kolesu

Okvir:
- aluminij 6061
- majhna teža, prožnost

Vilice:
- aluminij 6061
- vzdržljivost

Zavore:
- aluminijeva zlitina
- trdnost,prožnost



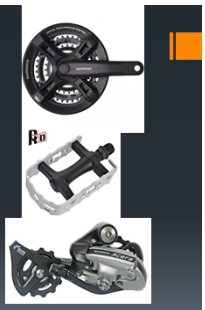


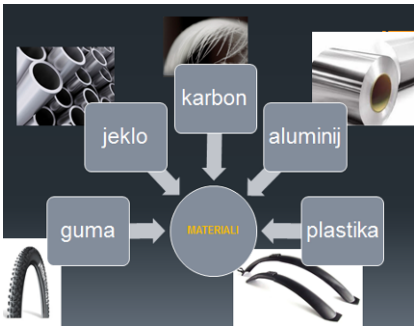
Gonilka

- kvalitetna aluminijeva zlitina
- majhna obraba

Pedala:
- jeklene zlitine, plastika
- vzdržljivost

Prestave:
- aluminij
- vzdržljivost



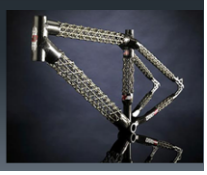


Možnost menjave s kvalitetnejšimi elementi

Okvir

obstoječi okvir

novi okvir



4th group: **Mechanical Transfer of Power**

Podatki o kolesu:

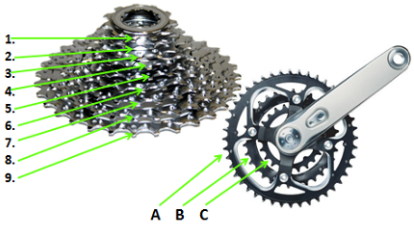
- Velikost kolesa: 28˝
- Prestave: spredaj 1, zadaj 9 zobnikov
- Teža kolesa: 19,6 kg
- Veriga: Shimano HG CN-HG53 veriga z valčki
- Menjalnik: Zadnji Shimano deore XT
- Dolžina pedalke: 180 mm
- Dolžina verige: 1486,8 mm
- Premer zavornega diska: 160 mm

Verižniki in prestavna razmerja

Št.	Št. zob	Koeficient	Premer	Prestavno razmerje
9	34	3,77	128,18	0,77
8	30	3,77	113,1	0,68
7	26	3,77	98	0,59
6	22	3,77	83	0,5
5	20	3,77	75,4	0,45
4	17	3,77	64,1	0,38
3	15	3,77	56,6	0,34
2	13	3,77	49,1	0,29
1	11	3,77	41,6	0,25

Prednji verižnik: 44 zob, premer verižnika: 165mm

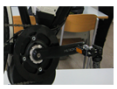
Prestavna razmerja pri navadnem kolesu



Preračun navorov na prvi gredi

- Pedalka pod kotom: 90°
- Velikost ročice: 0mm
- Navor:M= 0 Nm

- Pedalka pod kotom: 45°
- Velikost ročice: 0,707*0,18m
- Navor: M=89 Nm



- Pedalka pod kotom: 0°
- Velikost ročice: 0,18m
- Navor:M= 126 Nm = MaxNavor

Podatki o elektro motorju:

Oznaka	0 275 007 000/ 0 275 007 001
Moč	250W
Navor	50 Nm

$$Fv = \frac{M}{r} = \frac{226}{0,082} = 2756\,N = 275\,kg$$

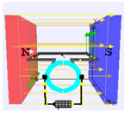
Izračun navorov, sil in pospeškov

M_1= 176 Nm	F_{p1}= 495 N	a_1= 0,56 g
M_2= 156 Nm	F_{p2}= 439 N	a_2= 0,49 g
M_3= 135 Nm	F_{p3}= 380 N	a_3= 0,43 g
M_4= 114 Nm	F_{p4}= 321 N	a_4= 0,36 g
M_5= 103 Nm	F_{p5}= 290 N	a_5= 0,32 g
M_6= 88 Nm	F_{p6}= 247 N	a_6= 0,28 g
M_7= 77 Nm	F_{p7}= 216 N	a_7= 0,24 g
M_8= 67 Nm	F_{p8}= 188 N	a_8= 0,21 g
M_9= 56 Nm	F_{p9}= 157 N	a_9= 0,17 g

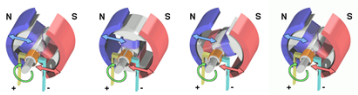
5th group: **Electric Drives**

1. DC motorji

- DC motor je električni motor , ki deluje na enosmerni tok (DC) električne energije.
- Enosmerni motorji lahko neposredno deluje od baterij za ponovno polnjenje.



DC MOTOR ROTATION



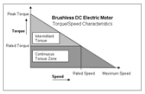
- Delovanje: deluje na principu el. sile na tokovodnik. Skozi navitje na rotorju teče tok, stator je permamentni magnet z smerjo S – J.
- Rotor se zasuče zaradi delovanja el. magnetne sile.
- Rotor se obrne po pravilu leve roke: če silnice prebadajo dlan prsti in tokovodnik, se zasuče v smeri palca.

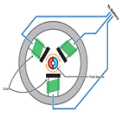
Brezkrtačni motorji

- **Brezkrtačni motorji = elektronsko komutirani motorji**
- **Črpajo energijo iz enosmernega toka**
- **Dodan elektronski sistem za preklapljanje - elektronsko vezje pretvarja enosmerno obliko napetosti v impulzno obliko**

ELEKTRO MOTORJI ZA POGON KOLES

- Brezkrtačni DC motor
- Motor je uporaben, zato ker ima močan navor in mu lahko spreminjamo vrtljaje

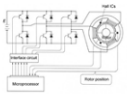


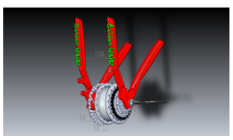


Tipi motorjev, ki so uporabljeni pri električnem kolesu ter njihovi osnovni podatki

Model:	PM-12	PM-24	PM-36	PM-48
Zunanji premer(mm)	120	158	158	158
Širina(mm)	50	50	50	50
Moč(W)	75	180	300	500
Napetost(Vdc)	12/24	24	36	48
El. tok(A)	10.2	10.8	11.2	15.4
Hitrost(RPM)	1600	3300	3000	4200
Izkoristek (%)	68	76	80	82
Teža(Kg)	0.7	1.5	1.8	2.0

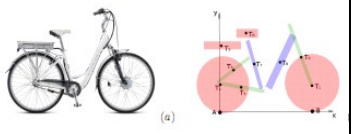
Konstrukcija motorja





6th group: **Resistance and Loss**

Računanje težišče telesa



Elementi	Ai [m^2]	xti [m]	yti [m]	Ai * xti [m]	Ai * yti [m]
1	0,01196	0,23	0,304	0,00275	0,00364
2	0,012	0,166	0,492	0,00199	0,0059
3	0,0205	0,47	0,56	0,00964	0,01271
4	0,03053	0,72	0,62	0,02198	0,01893
5	0,02952	0,95	0,72	0,02804	0,02125
6	0,3217	0	0,32	0	0,10294
7	0,3217	0,115	0,32	0,037	0,10294
Σ	0,74791	/	/	0,1014	0,26831

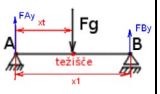
$$y_T = \frac{\Sigma A_i \cdot y_i}{A} = 0{,}35875\text{m} \qquad x_T = \frac{\Sigma A_i \cdot x_i}{A} = 0{,}13558\text{ m}$$

Izračun sil v kolesih

Xt=0.14m
Fy=204N

∑Ma=0
MFg+MFBy=0
-Fy Xt +FBy X1=0
FBy X1 =Fg Xt
FBy=30,06 N

∑Fy=0
FBy+FAy-Fy=0
FAy=-FBy+Fy
FAy=173,937
FAy=174N



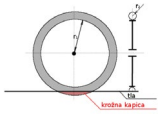
Kotalno trenje

- Nastane zaradi kotalenja kolesa,kar povzroči nakotaljevanje (problikovanje gume ko je v stiku z cestiščem).
- Formulo smo dobili v reviji Presek.

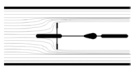
$$F_{ktr} = \frac{1}{p\pi} k_{tr} \frac{F_g^2}{p(r_1 r_2)}$$

sprednje kolo 0,0021N

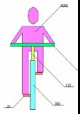
zadnje kolo 0,0048N



Zračni upor



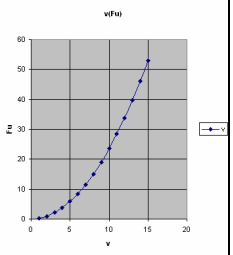
- Največji dejavnik pri izgubah
- Glede na hitrost se kvadratno povečuje
- Kvadratni zakon upora:



$$F_u = c_u \frac{1}{2} S \rho v^2$$

Sila zračnega upora — Koeficient zračnega upora — površina — gostota zraka — hitrost

Fu [N]	v [m/s]
0,23513	1
0,94052	2
2,11617	3
3,76208	4
5,87825	5
8,46468	6
11,52137	7
15,04832	8
19,04553	9
23,513	10
28,45073	11
33,85872	12
39,73697	13
46,08584	14
52,90425	15



7th group: **Voltage Sources and Charging**

UPORABA KOLESA

- Polnjenje akumulatorja

UPORABA KOLESA

- Števec

- Obstaja več načinov vožnje:
- ECO
- TOUR
- SPORT
- SPEED

AKUMULATOR NA KOLESU

BOSCH-ov Li-ionski akumulator:

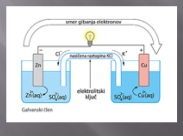
- Z enim polnjenjem akumulatorja lahko prevozimo od 48 do 56 km.
- Akumulator ima približno 500 ciklov uporabe.

Lastnosti akumulatorja

- 36 V
- 8 Ah
- Ima 80 celic
- Teža akumulatorja je 2,3kg

Delovanje akumulatorja

- Akumulator deluje na principu galvanskega člena
- Proizvajanje elektronov
- Pri praznjenju se tvori svinčev sulfat
- Žveplena kislina se pretvori v vodo



Baterije

- V baterijah je uskladiščena kemijska energija, ki se ob uporabi (priključitvi) pretvarja v električno energijo.

8th group: **Testing and Reversibility (charging while driving downhill)**

ZGODOVINA

Comte de Sivrac - 1791
- nožni pogon
- togo sprednje kolo
- zavijanje z nagibanjem

Kirkpatrick Macmillan - 1839
- pedala

Karl Drais von Sauerbronn - 1816
- udobnen sedež
- vodljivo sprednje kolo

James Starley - 1870
- prestave

Henry John Lawson - 1874
- verižni pogon

John Boyd Dunlop - 1888
- gumijasta zračnica

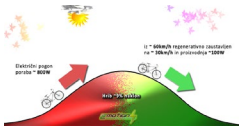
ELEKTRIČNI POGON

- **Pedelec -** Pogon električnega motorja soodvisen od potiskanja pedal (brez potiskanja ni električnega pogona).

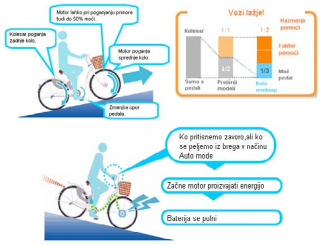
- **Ebike -** Pedala in motor neodvisna drug od drugega.

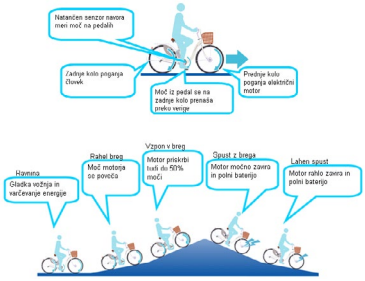
REGENERACIJA ENERGIJE

Pri zaviranju se energija pretvori iz kinetične energije v električno in shranjuje preko kemične nazaj v baterijo oz. akumulator.



POLNJENJE AKUMULATORJA MED VOŽNJO NAVZDOL





PRIHODNOST

- Novi viri energije
  - gorivne celice
  - sončne celice
  - ultrakondenzatorji

- Zanimive oblike

The project week was concluded with a final joint presentation by the students in the great lecture room for their parents, teachers and invited guests. The aplause that followed the presentation was a proof of a good, enthusiastic and dilligent professional work of the students as well as their mentors.

The presentation of the Project Week for teachers, students, their parents and invited guests.

In the end we carried out the evaluation of the Project Week among the students and teachers.

The evaluation of the Project Week- students

1. The work during the project week is different from regular classes. Did you like this kind of work?		
yes 58 %	partly 32%	no 10 %
2. Do you think the project week was connected with your regular work in a sensible way?		
yes 61 %	partly 30 %	no 9 %
3. Did you actively co-operate with your classmates in the group?		
yes 84%	partly 16 %	no 0 %
4. Were the materials easy to understand?		
yes 57%	partly 38 %	no 5 %
5. How would you grade the teacher's work?		
well-led 79 %	I would need more teacher's help 15 %	I did not know exactly what to do 6 %

The evaluation of the Project Week – participating teachers

	Agreement
1. The topic of the project week was wide enough and enabled interdisciplinary teaching.	92%
2. The objectives we set ourselves for the project week are in accordance with the objectives in the National Curriculum	86%
3. Appropriate methods and work forms were chosen to reach our objectives.	82%
4. We had enough time to accomplish all our objectives.	78%
5. We were able to monitor and evaluate the work of the students all the time.	82%
6. Interdisciplinary linking with our colleagues in the project week preparation was successful.	78%
7. Interdisciplinary linking with our colleagues in the project week implementation was successful.	78%
8. The students achieved the expected learning objectives during the project week.	86%
9. The students developed their social skills and other ICC during the project week.	89%
10. The work followed the scheduled timetable.	96%
11. The classrooms met the requierements.	96%
12. All the necessary material was available.	96%

The responses in the survey show that the students like the discovery of new horizons in this way much more than in the traditional way, and the knowledge gained is longer lasting. The teachers, especially the mentors, on the other hand, have more preparation to do and put in more personal involvement for a successful implementation of this teaching method.

FUTURE STEPS

Additional value – cooperation between a student and a company

During the project week we were visited by a repairman from Proloco Trade d.o.o. company which lent us the electric drive bicycle in the first place. The repaiman mentioned the problem of ventilating the hydraulic suspension forks when servicing classical bicycles.

One of the students found the problem interesting. He contacted the company and the repairman and, as a project assignement, constructed an automated device for ventilating the suspension forks which is now used in different bicycle repair shops. He used the method of project work and with the help of a mentor from SC Kranj and another from the company designed the device for ventilation. The device is now mass produced and used in bicycle repair shops.

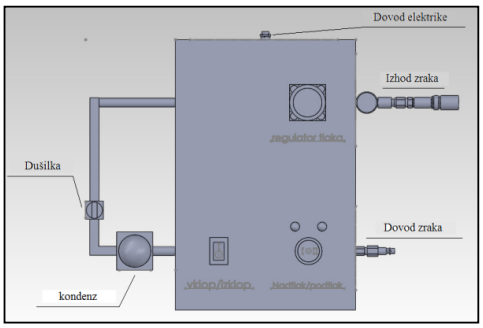
The forks of a bicycle work on the system of damper where oil is used to suppress the vibrations that are transfered from the road surface to the cyclist. During maintenance and oil change air bubbles enter the system so the effect of suspension and comfort is reduced. Consequently, all the air bubbles must be removed from the system. This can be achieved with a device that creates alternating overpressure and depression in the system. Overpressure pushes the air bubbles to the surface and depression removes them.

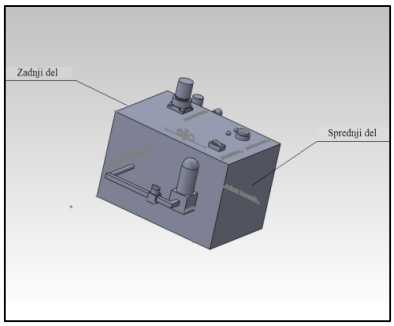
The previous device of an Italian producer was manually operated. Each valve had to be opened separately. The work was time-consuming due to numerous valves and high frequency of their opening and closing. There was a need for an automated device that can generate depression and overpressure just by pushing a button. This enables the operator to switch between the modes easily. The switch has three position modes, namely OFF, OVERPRESSURE and DEPRESSION.

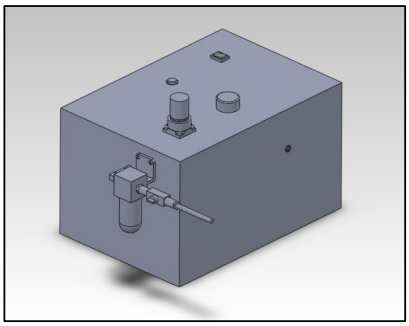
The project was realized by project work and carried out in the following steps:

- Defining the assignement/ describing the problem,
- Survey of the market, Pregled obstoječega stanja na tržišču.
- Designing the concept: at least three different designs,
- Setting the term plan of activities,
- Designing the preliminary study of the chosen model together with a mathematical model and basic calculations,
- Elaboration of the plan with the descriptions of operation, materials, etc.,
- Preparing a computer simulation,
- Testing the circuit operation,
- Manufacturing the device,
- Preparing technical documentation,
- Preparing marketing material,
- Marketing the device.

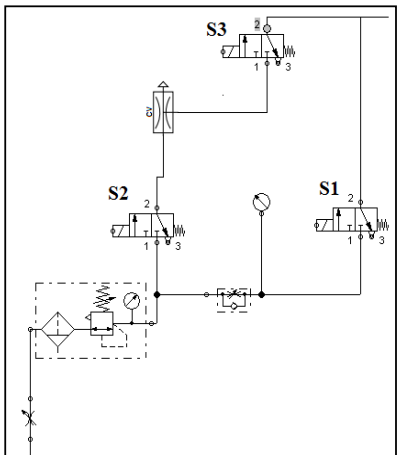
The device concept :



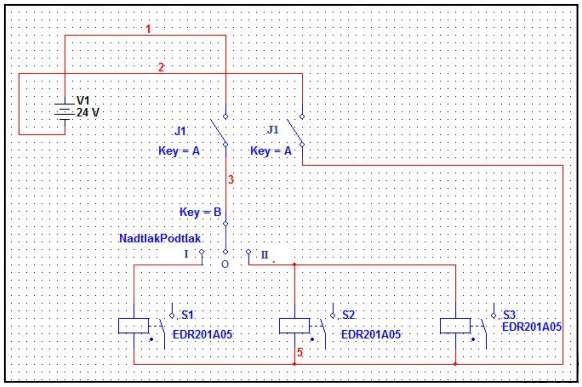




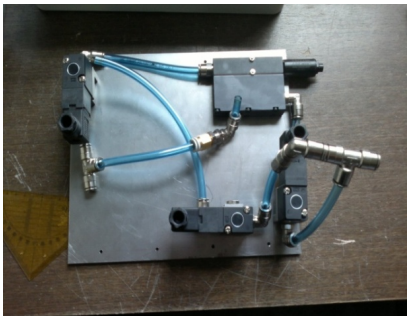
Pneumatic scheme

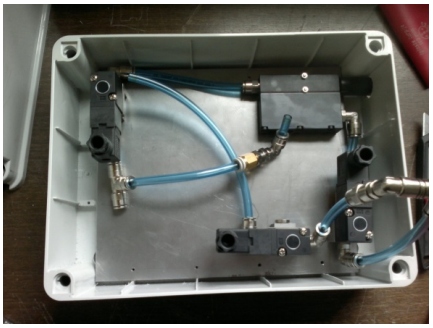


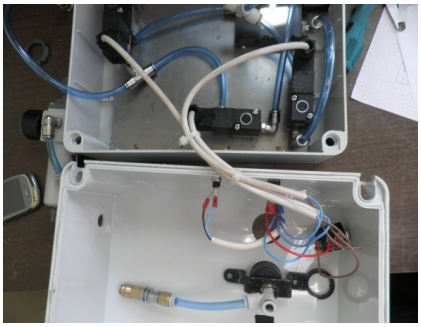
Electric circuit scheme

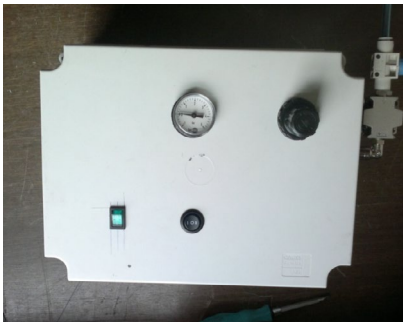


The assembly of individual elements









Final product

After the assembly it was necessary to check whether the device works in accordance with the expectations and task requirements. The testing was carried out in a classroom at SC Kranj. All those who contributed to the realization of the project were present. The testing was carried out by a representative of Proloco Trade d.o.o. company. The device performed in accordance with the requirements. Using the overpressure the oil gathered at the top of the bicycle forks and by means of depression the air bubbles were pressed out of the forks into the oil reservoir. At the same time, the device is very user-friendly: it is manageable and easy to use.

The device is used regularly by the repairman and 5 devices were sold to other repair shops in the first year of its marketing.

This quotation of the students is very interesting:

> *»I learned a lot from the project assignement because I made almost everything by myself. Some things were new to me but I figured them out eventually. I liked working with the industrial robot very much as it enabled me to learn some important things I hadn't known before. I gained a lot of good experience which will surely help me with my studies and finding a permanent employment.«*

We are going to continue with such successful work in future.

An example of a commercial leaflet for marketing the device:

CONCLUSION

Problem-oriented lessons with a project-work method of teaching is one of the ways to motivate students to find relations between general and technical knowledge, to a maximum activity and responsibility, cooperation in groups and developing resourcefulness. The Project Week frame could be a good method to take advantage of the students' interests and to thoroughly study a given topic. The students like this approach better than traditional teaching method and the knowledge gained by the project-work method is longer-lasting. On the other hand, it requires more preparations and organization from all the participating teachers – mentors. Nevertheless, the satisfaction of students is more important than our efforts.