MMaMS 2012

Design and Development of Lift Didactic Model Within Subjects of Mechatronics

Michal Kelemen* , Michal Fabiana, Tatiana Kelemenová

"Technical University of Košice, Faculty of Mechanical Engineering"

Abstract

The paper is directed to the problems of the reduced functional and didactic lift model applied in the education at the university. This didactic tool should support the concept of education applied through the project-based learning. The education conceived by this method is based on the fact that during the process of the problem task solving and the same through the modelling of the problem situations the students are earning their creative activity experience and they are creatively learning the knowledge about the way of the problem task solving. The model enables the students to imitate various lift operational phases oriented mainly both on the safe transportation of the people and on the elimination of the equipment damage risk resulting from its operation. In the same way it serves for the practical verification of the lift control operational program and the typical tasks related to the operation of this equipment model and the research tasks practically solved through the real model of the equipment.

Keywords: Education; laboratories; mechatronics; problem-solving

1. Introduction

The paper concerns the construction of the functional reduced didactic lift model developed for the educational purposes. The dominant aim of both the design and the development of this didactic model are to support the didactic methods actually applied at the education within the study program of the Mechatronics.

The effort is to set up the solution corresponding with the construction of the real lifts and the real operational phases should be imitated with this equipment. Some functional parts of the lift are simplified for the purpose of the simple realization of the equipment and nevertheless with no limitation of the functionality of the model.

This operational model was developed by the students during the process of elaboration of the term projects and the bachelor and the master theses. In 2006 the initial projects were realized with this model and they are continuing up today. Within the scope of the practical the students may practically test their knowledge earned during the application of the sensors and the actuators and the control units and with the programming of the lift control subsystem. This way the mechatronics may literally go to the student hands and on the equipment of their daily contact [1, 2, 3, 4, 5, 6].

* Corresponding author.
E-mail address: michal.kelemen@tuke.sk.
2. Didactic methods and the facilities

During the educational process it is important for students to absorb the theoretical knowledge earned during the lectures and then to realize it practically in the laboratories. The level of the presented absorption of the knowledge depends, to a great extent, on realized cognitive methods and utilized didactic tools. The proposed didactic model is supporting the applied educational approach by solving the defined problem situation. This approach, first of all, applies the problem interpretation-method and heuristic and the research methods. The problem solving philosophy of the education is based on the fact that during the problem task solving and the same by the model situation problem solving processes the students are acquiring the experience from their creative activity and they are creatively mastering their knowledge and the ways of their activity. The students are joining the problem searching and problem solving processes through the activities of the teacher. This way the students are learning how to earn the new knowledge independently and they are applying their earlier acquired knowledge and along with it they are personally experienced from their creative activities. The practical realization of the task and the personal involvement in problem solving are imitating the team work and the individuals may be aware of their importance within it. This approach is also of psychological and social natures both for the individual person and for the realization team.

The creative thinking rises during the problem solving situation when the student collides with an obstruction, some difficulty in his activity, some conflict if he impacts something unknown and uneasy and surprising and incomprehensible, whereas he does not know the way of overcoming the problem or the obstruction and he can not solve it on the basis of his actual knowledge. In other words, the mechatronics is not only about the lectures and it has to pass to the students’ hands. So that the hands may act, they are directed by the brain. The brain has to think what directive to get out and what activities will be performed by the hands. If something is coming to the student’s hands really it means the integral chain of consideration and researching and the individual study and consultations among the team members and also with the pedagogue who is both the guardian and the anchorman of the entire project. In this manner the students are learning the philosophy of the mechatronics approach to the project of the products. Their, both the thinking and the creativity, are getting a new dimensions enabling the student’s capability to get under better control the problem situations solving in the practice. And this manner trained graduates markedly increase the probability of their practice. The same they may to fortify the competitiveness of their employers [6, 7, 8, 9].

The design of the architecture of the model is modular and thus enabling an operative alteration of both the hardware and the software configurations.

The overall arrangement of the lift model is projected with the CAD systems support, with specific components and several mechanisms designed for particular lift function (fig. 1). The important role plays the imitation of some operational elements moving based on, what is possible to consider as, the applicability of selected construction elements.

Fig. 1. Virtual lift model and its applied realization.
3. Didactic lift model functions

The didactic lift model consists of four floors. This number of floors is fully sufficient for the imitation of the operational phases of the equipment. On any floor may be waiting „active traveller” initializing the lift call through the control panel. From the control point of view the lift model is equipped with the function detecting the presence of the persons in the cabin. This function shall to provide the performance of the demand of the higher priority of putting the commands from the cabin and it shall prevent the void commands resulting from the user error or lack of the discipline. The active floor also safely prevents the lift cabin overloading. This manner increases the safe operation of the equipment and the same the protection and the reliability of the driving mechanism.

The cabin includes the interior lighting activated only in presence of the passenger.

**Indication of the cabin position** on the floors is realized with this didactic model too. On any floor the model is equipped with the module indicating the cabin actual position. The indication is made up of the light LED diodes. The indication of the cabin position is installed also in the cabin, and in our case, on the cabin external side, in order to give the commands safely even during the cabin movement (fig. 2).

![Fig. 2. Cabin control panel and the indication of the cabin position.](image)

The construction of the model enables the realization of both the smooth start and the slowdown of the lift cabin, and regarding the user’s comfort, these are the important functions. Thanks to the smooth start and the run down of the cabin the impacts are eliminated and highly affecting the prolongation of the cabin construction operating life and the same of the driving mechanism. For the purpose of the cabin model movement control there is designed the function detecting the cabin position. The sensing of the position was designed so that to enable the safe detection of the cabin position even during the breakdown of the power supply. This function increases the safety of the passengers in case of the crisis situations like the fire, resp. the evacuation of the building. Early detection of the locked up persons increases their chance of soon rescue and their lifesaving.

The model disposes of the **continuous close-open door function** – on respective floor the door is not opening by step and it is opening by continuous start or by slowing down the closing (fig. 3). This solution results in extended operating life of the mechanisms in the real practice.

![Fig. 3. Door control mechanism.](image)
The lift call on the floors – when calling the cabin of the lift there is the possibility to enter the direction of the travel required by the passenger. The second and the third floors will be designed the same way. On the first and on the last floors there will be of course only one choice. The lift model is equipped with the safety end switches preventing the system crash in case of the system failure or a faulty projected control algorithm. This feasibility will be provided by the end crash stops located at the end positions of the cabin movement path. The safety end switches do not depend on the projected control algorithm and other lift functions at all.

Besides the push-buttons entering the choice of the final floor the lift cabin includes also the emergency push-button STOP and after it is pressed the lift shall immediately stop. After the push-button operation there will be the possibility to choose new requirements of the transportation. The possibility of the new requirements option is disposable also in the situation of the malfunction resulting from the blackout when the cabin stops in an incidental position.

The lift model disposes of several safety elements preventing the risk of the model user injury when his operation is improper. The function of the optoelectronic sensing of the passenger presence within the door area is disposable too, whereas if the passengers or other objects are presenting at the door, the closing of it does not occur.

4. Realization of the didactic lift model

The total height of the model is app. 500 mm so that the handle of it should be simple. The model construction consists of two base planar boards connected with the supporting pillars. On the pillars there are guidance rails of the cabin movement. On the bottom base board there are located all electronic modules. On the upper base board there are located the actuator and the gear drive mechanisms providing the cabin movement.

Regarding the provision of the cabin motion there was selected an actuator – the direct-current motor whereas the transfer of the torque is ensured by the gear with the gear-wheels to the motion screw which in connection with the motion nut bolt transforms the rotational motion to the linear motion of the cabin. The lift cabin is attached with the motion bolt nut and consequently the rotation of the motion screw is resulting in the linear motion of the lift cabin. (fig.4, 5).
The function sensing both the passenger presence and the overloading of the cabin is realized through the double floor. The sensing of the weight of the objects inside the cabin is realized by sensing the deformation of the compression spring placed in the subfloor of the cabin (fig. 6).

![Double floor of the cabin with the sensor.](image)

Sensing of the cabin position is realized by the infrared transmissive optical sensor (break-beam arrangement) where the non-transparent element-flag is tightly connected with the cabin and thus, the light flux in the optical sensor through which the cabin with flag currently passes is interrupted during the cabin movement.

The didactic model consists of the electronic modules as follows:
- Microcontroller modules,
- Power transistor switch modules,
- Modules of the infrared optical break-beam sensing the lift cabin position,
- Modules of the infrared optical break-beam sensing the presence of the persons within the door area,
- Modules sensing the cabin occupancy (the weight of the passengers),
- Module of the low-pass filter for the cabin smooth (ramp) start by operating PWM (Pulse Width Modulation),
- Module of the cabin reverse movement,
- Modules of the control panels with the control push buttons,
- Module distributing the power supply of the each modules.

The each electronic module is realized like the separate boards of the printed circuits (PCB) and due to possible modification of the overall lift connection. The electric connection of the each module is realized through the systems of the precise connectors and the wire jumpers. So here is the space for implementation of other additional modules. Now there is established a new field, the next experimentation and creativity of the students.

During the first phase, and first of all the students have to build the hardware solution of the lift and through the wire jumpers, and during the next phase they shall arrange the realization algorithm of the solved functions. Then it is required to create the control program of the microcontrollers. Some modules were extended by the protecting elements preventing its damage under the improper handling. Some the protective covers and other safety elements were integrated to prevent the injuries of the students or the collisions with other objects. The protective covers are made of light and transparent materials providing the requirement of the visual education of the students.

Two single-board microcomputers - Basic Stamp 2P40 (master a slave) embedded on the boards are the heart of the entire model. The microcomputers may be applied independently and the same they may create a computer network.

The power supply of the entire lift model is ensured by the distribution module of maximum electric voltage 12V. The laboratory source of the electric voltage is out of the model. The students are operating only the low voltage, due to safety reasons.

The entire model represents the compact equipment and it is easy manipulating and removable at need.

### 5. Problem didactic situations, the heuristic approach, the researching methods

If the prepared and specific tasks are submitted by us to the students then we are relieving their creative and heuristic ambitions. We want the students to make their own definition of the problem. From that reason we are teaching them the right and self definition of the problems resulting from induced problem situations with this didactic model. By solving the problems the students are absorbing their new knowledge and experience and they are developing their creative thinking.
The solved problems are characterized by the fact that the students know the aim they want to reach and they do not know the way how to reach it. They have to discover the suitable way of problem solving by them.

Under the heuristic approach the teacher is managing the research and making the definition of the problems, he defines the contradictions, governs the students steps of the problem solving so that the students may master it, however both the method of identification and the particular steps of the solving are realized by the students themselves. In this case the team work of the students is effectively practiced and with the problem task solving there is successfully applied also the brainstorming.

The researching methods with the teacher specifying the problem situation and the students solving the work themselves are representing the highest level of the student cognitive process. The same are the solving of the complex projects and elaborations of the bachelor and master theses. From 2006, when this didactic model came to existence, the build-up and upgrade of it continues. By their active approach the students are changing the model appearance all the time. This manner the model takes new functions, the problem situations are solving and the faults are eliminated (fig. 7).

The work of us, the teachers, makes sense if we are teaching our students to think creative and independently [2, 4, 10, 11].

Fig. 7. Actual version of the didactic lift model.

6. Conclusion

During the period of the didactic lift model existence it is representing the possibility of the students’ self-realization and earning of their practice and it is highly important for their future profession. The model is one of many models effectively supporting the cognitive processes of the students. In this manner the students may solve the problem situations and to design and to create and to build various models both material and virtual, to experiment and to test the models or their parts and to examine and to compare the various situations. This fact leads the students to their aspiration to search the essential
information, to find the mutual communication and the team working, and it is our aim to lead the students in this manner [12, 13, 14, 15, 16, 17, 18, 19].

Acknowledgements

The authors would like to thank to Slovak Grant Agency – project VEGA 1/0085/12 and VEGA 1/1205/12. This contribution is also the result of the project implementation: Centre for research of control of technical, environmental and human risks for permanent development of production and products in mechanical engineering (ITMS:26220120060) supported by the Research & Development Operational Programme funded by the ERDF.

References

[1] Acar, M., Parkin, R.M., 1996. Engineering Education for Mechatronics, IEEE Trans. on Industrial Electronics, vol. 43, no. 1, pp. 106-112, Feb. 1996
[2] Daniels, M., Cajander, Å., Clear, T., Pears, A., 2010. Engineering Education Research in Practice: Evolving Use of Open Ended Group Projects as a Pedagogical Strategy for Developing Skills in Global Collaboration, Int. J. of Eng. Education, vol. 26, no. 4, Tempus publications, 2010
[3] Castles, R. T., Zephirin, T., Lohani, V. K., Kachroo, P., 2010. Design and Implementation of a Mechatronics Learning Module in a Large First-Semester Engineering Course, IEEE Trans. on Education, vol. 53, no. 3, pp. 445-454, Aug. 2010
[4] Ostojic, G., Stankovski, S., Tarjan, L., Senk, I., Jovanovic, V., 2010. Development and Implementation of Didactic Sets in Mechatronics and Industrial Engineering Courses, Int. J. of Eng. Education, vol. 26, no. 1, Tempus publications, 2010.
[5] Blaško, M., 2010. Introduction to Modern Didactics I., 2nd. rev. ed. Košice, KIP TU, ISBN 978-80-553-0462-5, 2010
[6] Baláž, V., Ostertagová, E., Pašák, D., 2006. Using of e-learning for teaching extension at KVTaR, Acta Mechanica Slovaca. Vol 10, No. 2-A (2006), s. 47-50. - ISSN 1335-2393
[7] Stankovski, S., Tarjan, L., Skrinjar, D., Ostojic, G., Senk, I., 2010. Using a Didactic Manipulator in Mechatronics and Industrial Engineering Courses, IEEE Trans. on Education, vol. 53, no. 4, pp. 572-579, Nov. 2010
[8] Chang, Ch., Lee, J., Chao, P., Wang, Ch., Chen, G., 2010. Exploring the Possibility of Using Humanoid Robots as Instructional Tools for Teaching a Second Language in Primary School, Journal of Educational Technology & Society, 2010, Vol: 13, Issue: 2, Pages: 13–24
[9] Das, S., Yost, S. A., Krishnan, M., 2010. A 10-Year Mechatronics Curriculum Development Initiative: Relevance, Content, and Results—Part I’, IEEE Trans. on Education, vol. 53, no. 2, pp. 194-201, May 2010
[10] Bradley, D., 2010. Mechatronics - More questions than answers, Mechatronics, vol. 20, no. 8, Special Issue on Theories and Methodologies for Mechatronics Design, pp. 827-841, Dec. 2010
[11] Lee, J. W., 2010. Investigation of mechatronic education in South Korea, Mechatronics, vol. 20, no. 3, (2010), pp. 341–345, April 2010
[12] Wang, Y., Yua, Y., Xiea, Ch., Wanga, H., Feng, X., 2009. Mechatronics education at CDHAW of Tongji University: Laboratory guidelines, framework, implementations and improvements, Mechatronics, vol. 19, no. 8, pp. 1346–1352, Dec. 2009
[13] van Beek, T. J., Erdena, M. S., Tomiyama, T., 2010. Modular design of mechatronic systems with function modeling, Mechatronics, vol. 20, no. 8, pp. 850-863, Dec. 2010
[14] Krishnan, M., Das, S., Yost, S. A., 2010. A 10-Year Mechatronics Curriculum Development Initiative: Relevance, Content, and Results—Part II, IEEE Trans. on Education, vol. 53, no. 2, pp. 202-208, May 2010
[15] Starzyk, J.A., Graham, J. T., Raif, P., Tan, A., 2011. Motivated learning for the development of autonomous systems Original Research Article Cognitive Systems Research, In Press, Corrected Proof, Available online 12 January 2011
[16] Šolek, P., Horinek, M., 2011. Actuator placement for active damping of vibration on two dimensional clamped plate, Acta Mechanica Slovaca, Vol. 15, No. 1 (2011) pp. 64-69, ISSN 1335-2393
[17] Trebuha, F., Smiček, J., Bobovský, Z., 2010. Kinematics of Self-Reconfigurable Robotic System. Acta Mechanica Slovaca, Vol. 14, No. 4 (2010) pp. 36-41. ISSN 1335-2393