GÁBOR BUDAI *

The effectiveness of the application of modern methodologies in technical vocational education

Abstract: In my study, I examined the applicability and effectiveness of the methodology of technical foundation courses. Within the basic technical education - in secondary education - the subject of machine components provides an overview of the history of components, the technical knowledge to be acquired in public education, the planning of the teaching of the subject and the possible methods of lesson organization. With my test results, I pointed out the importance of choosing the right teaching method, which is related to the students' academic results. I also pointed out that the success of teaching and learning also depends on the extent to which teachers can use ICT tools during education. The first part of the study presents the literature background. The second part of the study contains the test data and conclusions.
Keywords: Vocational training, secondary education, teaching methods. digital technology.

Összefoglaló: Tanulmányomban a műszaki alapozó tanfolyamok módszertanának alkalmazhatóságát és hatékonyságát vizsgáltam. A műszaki alapképzésen belül – a középfokú oktatásban – a gépelemek tantárgy áttekintést nyújt az alkatrészek történetéről, a közoktatásban elsajátítandó műszaki ismeretekről, a tantárgy tanításának tervezéséről és az óraszervezés lehetséges módszereiről. Vizsgálati eredményeimmel rámutattam a megfelelő tanítási módszer megválasztásának fontosságára, amely összefügg a tanulók tanulmányi eredményeivel. A tanítás és a tanulás sikere attól is függ, hogy a tanárok mennyire tudják használni az IKT-eszközöket az oktatás során. A tanulmány első része a szakirodalmi hátteret mutatja be. A tanulmány második része a vizsgálati adatokat és a következtetéseket tartalmazza.
Kulcsszavak: A tanulás és a tanulással kapcsolatos ismeretek; szakképzés; középfokú oktatás; tanítási módszerek; digitális technológia.

* *Dunaújvárosi Egyetem, Tanárképző Központ*
E-mail: budai@uniduna.hu

Introduction

A modern teaching method occurs when the knowledge leading to the solution of a particular problem is not given to students "ready", but they have to acquire it themselves, for example from various Internet sources, public collections, or even from teachers, parents and classmates. Since education is most often the result of interaction between teacher and student, modern methods include the procedures of both teacher and student. Educational methods should be understood as the whole path to the final goal, the way of processing the curriculum. In most cases, the quantity and quality of knowledge and activity content that becomes knowledge during the same diligence period depends on the method used. With my study, I point out that modern teaching methods used in professional classrooms can only be truly effective if the personal experiences of students and the "virtual" reality created by computer methods are present together during the demonstration.

Methodology for teaching technical foundation subjects

From the beginning of the 90s, the methodology of teaching professional subjects taught at secondary level was called by several names in the literature. The term "vocational methodology, didactics" is widespread, but it is often called subject methodology and subject pedagogy as well. The main difference between the names is which element their user emphasizes: the pedagogical components or the scientific content. Subject methodologies are applied sciences that cannot be classified as independent but complex disciplines, and due to their interdisciplinary characteristics, they cannot be classified as sub-disciplines of a larger science. There is a concept that considers professional methodologies as one of the components of didactics (pedagogy), a subscience of pedagogy, but this is difficult to justify because, similarly to didactics, it has similarly close connections with many other sciences. (Village 2021)

According to Szűcs, the long paradigm shift from the 1990s to the present day has brought about elementary and irreversible changes even in such a traditional complex system as the world of teaching and learning, and will bring about more and more in the future. Put simply, these changes are the result of internet communication and media, and in more detail, of being online, the information society, digital tools and interactive visual content.

Our mediatized world is in a permanent beta state, its gravitational core is trying to attract particles from more and more areas of life, so STEM (Science, Technology, Engineering and Mathematics) education needs to be put on new, innovative foundations. [1]

The aim of the methodology of technical foundation trainings is to promote effective professional teacher work (education and upbringing). Its task is to find, systematize, examine and develop effective teaching methods and tools. Within the technical foundation training, the machine elements subject - in secondary education - provides an overview of the history of mechanical components, the technical knowledge to be acquired in public education, the planning of the teaching of the subject, the methods of organizing classroom and extracurricular activities, the types of lessons, methods and teaching aids that can be used. (Village 2021: 90)

Social expectations about school and learning are changing dynamically. High school students do not interpret learning in the traditional way – frontally – therefore they learn in a different way, they can be introduced to the world of science in a different way, and they can be motivated in a different way. [2]

Among pedagogical disciplines, professional methodology is most closely related to didactics, which researches the general laws of education. The methodology of the technical foundation trainings applies the results of didactics during the transfer of mechanical engineering knowledge. Thus, didactics endows the didactic laws of the teaching process with specialities related to the teaching of a given subject within the framework of specialized methodology. The development of educational trends and age pedagogies also has a strong influence on subject methodologies. While in the 19th century the methodology of technical training was looking for effective methods of illustration and explanation, since the early 2000s the methods of cooperative group work and research, problem- and project-based learning have been the areas to be developed. Village (2021: 98) The effectiveness of vocational education at secondary level also depends on teachers knowing when to use digital technology and when to stick to traditional methods. [3]

The concept of "technical practice" also implies processes of "learning by working" and "incremental innovations", since it assumes that social actors constantly monitor the results of their own activities and change their way of acting if the results do not meet their expectations. The constant repetition of new technical practices leads to the institutionalization of new technical, organizational and cultural structures.

[1] Zoltán Szűcs (2020): The use of open curriculum in augmented reality-based illustration in the teaching of STEM subjects. In: András Benedek: *New methods in vocational education and training – Collaborative online content development.* Budapest: MTA Subject Pedagogical Research Program.

[2] Katalin Bekéné Zelencz (2021): *Innovative teaching methods, Sárospatak Pedagogical Booklets*. Eger: Eszterházy Károly University, Lyceum Publishing House.

[3] András Benedek (2020): *New methods in vocational training, Subject-pedagogical Research Programme of the Hungarian Academy of Sciences,* Budapest.

The concept of a 'feedback loop' establishes a link between technical practices and 'learning by working' on the one hand, and incremental innovation on the other. [4]

Since illustration is an indispensable method of teaching machine elements in secondary education, it has always been sensitive to the modernization of educational technology tools that help this. The educational technology tools, renewed almost every decade since the early 90s, also revolutionize professional methodology. For example, the "chalk board drawings" that were once used in classrooms are now unknown to many people exactly what purpose they served. At the time of writing my paper – in 2024 – digital whiteboards, CAD design software, web tools and e-learning methods require completely new approaches, restructuring of the curriculum and introduction of new teaching methods. The programme curricula used in VET also highlight the importance of modern teaching methods (e.g. project work). *(Example: Program curriculum in section 10. Mechanical engineering technology technician profession: Production design subject, Project work: In the learning process, students combine their knowledge in computer-aided design (CAD) with their knowledge in technological design and computer-aided manufacturing (CAM). Based on these, they are able, for example, to design two- or three-axis machining using the technology of the associated operation elements. They can create the tool paths of the tools used in production with the help of CAM software, and then with the CNC program they create them, they can carry out the production on the given CNC machine tool, and they can detect and correct any errors that occur during this. They can apply the simulation possibilities provided by CAM software and are able to correct any errors. Based on the prepared machining plan, they can prepare production documentation. Source: PTT_Gepeszet_Gepgyartas-technologiai_technikus_2020 (ikk.hu)*

Investigation

With my examination, I point out how students studying Mechanical Engineering Technology Technician meet the requirements of the Machine Elements subject.

Two study groups were observed. In one group, students studied the subject in the 2021–2022 school year, and in the other group, in the 2022-2023 school year. The place of study for both groups was one of the Technical Technical Schools (school-based, full-time education) in Dunaújváros.

[4] György Molnár (2008): Requirements and development opportunities of ICT-supported learning environment. *Vocational Training Review,* Budapest.

[5] Beáta Kotschy (2021): Planning educational work in schools. In: Iván Falus: *Didactics,* Budapest: Akadémiai Publishing House.

My hypothesis: With my study, I point out that modern methods used in classes can only be truly effective if the personal experiences of students and the teaching methods supported by IT tools – the "virtual" reality – are present together during the demonstration.

For the preparation of the study (comparison of the two groups) I used the steps of thematic planning. "During thematic planning, the teacher already has most of the necessary information, knows what results he has achieved in the previous parts of the curriculum, what knowledge he can expect and what he needs to replenish, or what are the problematic points on which he should put more attention."

Comparative analysis of curricula belonging to study groups

Study group 1: Mechanical Engineering Technician Degree Programme (5452103): The class started in September of the 2018/2019 academic year within the framework of a 4+1 year training. The relevant VET framework curriculum did not contain any methodological recommendations.

The 'Basic tasks in mechanical engineering' module (10162–12) includes the studied 'machine elements' subject. The number of hours taught in the 11th grade: 72 hours/academic year (2021–2022 academic year).

The study group consisted of 10 students.

Study group 2: 10. Mechanical engineering sector (5 0715 10 05) Mechanical technician specialisation CAD/CAM (5 years technical training)

The class started in September of the 2020/2021 academic year. The relevant programme curriculum did not contain any methodological recommendations. The 'Mechanical Engineering' module includes the 'Machine elements' subject studied.

The number of hours taught in the 11th grade: 72 hours/academic year (2022/2023 academic year).

The study group consisted of 10 students.

Comparative analysis of topics

Main topics of the 1st semester:
– 1. Knitting machine elements
– 2. Springs, shock absorbers
– 3. Tanks, pipes, pipe fittings
– 4. Shafts and bearings

[6] https://ikk.hu/gepeszet_gépgyartas-technikus (Download: 12. 12. 2024)

Main topics of the 2nd semester:
– 5. Clutches
– 6. Brakes
– 7. Sprouts
– 8. Mechanisms

Definition of working methods in the classroom

For the first study group, the following methods were used: Presentation, frontal work; Group work, Pair work, Independent observation of the student.

For the second study group, I also applied the methods listed above, supplemented by the 'Project Work' method, which is provided by the program curriculum.

Project work: "The learning process connects the learning islands of different mechanical engineering subjects in the implementation of complex problem-solving tasks. It is recommended to process the (...) topics under teacher guidance, partly independently." [6]

Comparative analysis of working methods

The following tables show how I adapted the working methods I used for the first study group in the 2022/2023 academic year.

1. table.Teaching methods used in the topic Knitting Machine Elements

Row.	Machine elements course topics	Method 2021/2022 academic year	Method 2022/2023 academic year
	1. Knitting machine elements		
1.	Concept, grouping of machine elements.	lecture, frontal work	lecture, frontal work
2.	Knitting machine elements, rivet jointing.	lecture, frontal work	lecture, frontal work
3.	Types of rivets, ways to form a joint.	Pair work	Pair work
4.	Rivet joint strength dimensioning. Design of a cut-punch tool unit.	lecture, frontal work	PROJECT WORK
5.	Welded joint.	Groupwork	Groupwork
6.	Characterization of welding seams.	lecture, frontal work	lecture, frontal work
7.	Welded joint strength dimensioning.	lecture, frontal work	lecture, frontal work
8.	Soldered, glued joints.	Groupwork	Groupwork
9.	Shrink joint formation and sizing.	lecture, frontal work	lecture, frontal work
10.	Bolt connections.	lecture, frontal work	lecture, frontal work
11.	Standard screws and nuts.	Groupwork	Groupwork
12.	Bolt locks.	lecture, frontal work	lecture, frontal work
13.	Moving screws. Screw lift design.	lecture, frontal work	PROJECT WORK
14.	The torque requirement to tighten and release the bolt.	Groupwork	Groupwork
15.	Strength sizing of knitting screws.	Self-observation of a student	Self-observation of a student
16.	Formation and sizing of nail and pin joints.	Groupwork	Groupwork
17.	Creation of wedge and latch joints, strength dimensioning.	Groupwork	Groupwork
18.	Ribbed shaft, conical joints.	lecture, frontal work	lecture, frontal work

2. table. Methods used for teaching springs and shock absorbers

Row.	Machine elements course topics	Method 2021/2022 academic year	Method 2022/2023 academic year
	2. Springs, shock absorbers		
19.	Task of springs, grouping.	lecture, frontal work	lecture, frontal work
20.	Material and manufacture of springs.	lecture, frontal work	lecture, frontal work
21.	Springs loaded for bending	lecture, frontal work	lecture, frontal work
22.	Springs for twisting	Pair work	Pair work
23.	Coil springs. Linear system design.	lecture, frontal work	PROJECT WORK
24.	Rubber springs	lecture, frontal work	lecture, frontal work
25.	Shock absorbers	Self-observation of a student	Self-observation of a student
	3. Tanks, pipes, pipe fittings		
26.	Pipes, pipe fittings, pipe joints.	lecture, frontal work	lecture, frontal work
27.	Determination of pipe wall thickness.	Self-observation of a student	Self-observation of a student
28.	Materials of pipes, production. Universal cutting machine cutting design	lecture, frontal work	PROJECT WORK
29.	Applications of taps, valves, latches	lecture, frontal work	lecture, frontal work

3. table. Methods used for teaching shafts and bearings

Row.	Machine elements course topics	Method 2021/2022 academic year	Method 2022/2023 academic year
	4. Shafts and bearings		
30.	Characterization, materials, dimensioning of axes.	lecture, frontal work	lecture, frontal work
31.	Structural elements and dimensioning of bearings, plain and rolling bearings.	lecture, frontal work	lecture, frontal work
32.	Types of rolling bearings. Maintenance process planning.	lecture, frontal work	PROJECT WORK
33.	Bearing installations, lubrication and sealing of bearings.	Groupwork	Groupwork
	5. Clutches		
34.	General characterization of clutches.	lecture, frontal work	lecture, frontal work
35.	Types of clutch and strength dimensioning.	lecture, frontal work	lecture, frontal work
36.	Rigid clutches	Self-observation of a student	Self-observation of a student
37.	Flexible clutches	Groupwork	Groupwork
38.	Balancing clutches	lecture, frontal work	lecture, frontal work
39.	Friction clutches	lecture, frontal work	PROJECT WORK
40.	Automatic clutches	Groupwork	Groupwork
	6. Brakes		
41.	Design and general characterization of brakes.	lecture, frontal work	lecture, frontal work
42.	Sizing and operation of brakes.	lecture, frontal work	lecture, frontal work
43.	Disc brake, Band brake, Conical brakes	Groupwork	Groupwork
44.	Single-jaw and double-jaw brakes. Design of hydraulic and pneumatic operation.	lecture, frontal work	PROJECT WORK

4. table Methods used to teach the Shoots topic

Row.	Machine elements course topics	Method 2021/2022 academic year	Method 2022/2023 academic year
	7. Sprouts		
45.	Torque transfer drives based on friction:	lecture, frontal work	lecture, frontal work
46.	The principle of operation, application, force and movement of the friction drive.	lecture, frontal work	lecture, frontal work
47.	Inspection and maintenance of friction drive.	Self-observation of a student	Self-observation of a student
48.	Principle of operation, application, characteristics of flat belt and V-belt drive.	Groupwork	Groupwork
49.	Belt drive machine elements (pulleys, belts, belt tensioners).	Groupwork	Groupwork
50.	Flat belt drive sizing.	lecture, frontal work	lecture, frontal work
51.	V-belt drive installation, dimensioning.	lecture, frontal work	lecture, frontal work
52.	Selection of standard V-belts from standards.	Groupwork	Groupwork
53.	Forced-link torque transfer drives. Gear gear design.	lecture, frontal work	PROJECT WORK
54.	General characterization and geometric dimensioning of bevel gears.	Groupwork	Groupwork
55.	Characterization and sizing of worm drive.	lecture, frontal work	lecture, frontal work
56.	Efficiency of worm drive.	lecture, frontal work	lecture, frontal work
57.	Chain drive design.	Groupwork	Groupwork
58.	Machine elements of chain drive, layout solutions.	lecture, frontal work	lecture, frontal work
59.	Dimensioning, inspection, installation of the chain drive.	Groupwork	Groupwork
60.	Task, types of industrial actuators.	Groupwork	Groupwork
61.	Characterization and sizing of main and auxiliary engines of machine tools.	lecture, frontal work	lecture, frontal work

62.	Speed limits, controllability for graduated and continuously variable gearboxes.	lecture, frontal work	lecture, frontal work
63.	The degree factor.	lecture, frontal work	lecture, frontal work
64.	Control of actuators.	lecture, frontal work	lecture, frontal work
65.	Hydraulic actuators.	Groupwork	Groupwork

5. table. Methods used in teaching the topic of mechanisms

Row.	**Machine elements course topics**	**Method 2021/2022 academic year**	**Method 2022/2023 academic year**
	8. Mechanisms		
66.	The concept of mechanisms	lecture, frontal work	lecture, frontal work
67.	Planar lever mechanisms	lecture, frontal work	lecture, frontal work
68.	Doorknob works. Design of complex project tasks.	lecture, frontal work	PROJECT WORK
69.	Cam mechanisms	lecture, frontal work	lecture, frontal work
70.	Hanger mechanisms	lecture, frontal work	lecture, frontal work
71.	Spherical (centois) mechanisms	lecture, frontal work	Groupwork
72.	Spatial damage mechanisms	lecture, frontal work	lecture, frontal work

Educational technology tools used in education

Chalk board, Felt board, Computer (with design software) CAD-CAM, Projector, Digital whiteboard (with software)

Results of the investigation

The grades obtained with the final papers are summarized in *table 6*:

table 6. Feedback:	**Averages of final thesis papers (group average)**	
Topics	**academic year**	
	2021/2022 (Without project work)	**2022/2023 (With project work)**
1st semester:		
1. Knitting machine elements	2,25	2,86
2. Springs, shock absorbers	2,41	2,67
3. Tanks, pipes, pipe fittings	2,35	2,5
4. Shafts and bearings	3,02	3,08
2nd semester:		
5. Clutches	2,05	3,11
6. Brakes	2,65	3,01
7. Sprouts	2,5	2,65
8. Mechanisms	3,05	3,25
Average:	**2,53**	**2,89**

The results show that the results of the study in the 2022/2023 academic year (group 2) have improved, which can be traced back to a more thorough choice of teaching methods. Thus, I consider my hypothesis to be justified.

Summary

With my comparative study, I pointed out that the quantity and quality of knowledge and activity content that becomes knowledge in time intervals of the same examination length depends crucially on the method used. With my study, I also pointed out that the modern educational technology methods used in the classroom, supported by IT tools, can only be truly effective if the personal experiences of the students and the "virtual" reality created by computer methods are present together in the framework of project work.