STUDIA UBB PSYCHOL.-PAED., LXXI, Special Issue, 2026, p. 117-129
(Recommended Citation)
DOI:10.24193/subbpsyped.FOHE.7

Developing Learning Techniques While Learning Modern Teaching Methods Within the Framework of *Teaching Methodology of Chemistry* and *Didactics of Science Subjects*

Csilla SÓGOR[1]

ABSTRACT. In recent years, university instructors have observed that first-year students enrolled in the Faculty of Chemistry and Chemical Engineering possess a level of subject knowledge considerably below expectations, with many exhibiting fundamental deficiencies. Among students enrolled in the Hungarian-language programs of Chemistry and Chemical Engineering, 70% choose to complete the pedagogy module. Of these, 13.6% intend to work exclusively as chemistry teachers, while 18% remain undecided regarding their future career path. The rest plan to pursue research or engineering careers but do not exclude the possibility of teaching.

At the beginning of their studies, 40% of respondents expressed the hope that the methodology courses would help them become more confident professionally and improve their own learning techniques.

The first part of this study, the literature review, presents the thematic content covered in the methodology courses designed to develop students' key competencies—skills they will later need to cultivate in their own pupils when teaching chemistry. The second part examines students' learning habits, exploring how the pedagogy module contributes to their ability to develop autonomous and reflective learning strategies.

Keywords: Methodology of Chemistry Teaching, students learning habits, students learning techniques pedagogical content knowledge, chemistry teacher training.

[1] Faculty of Chemistry and Chemical Engineering, Babeş–Bolyai University, Cluj-Napoca, Romania, csilla.sogor@ubbcluj.ro

©2026 STUDIA UBB PSYCHOL.-PAED. Published by Babeş-Bolyai University.
This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License

1. Literature Review

The transforming landscape of education increasingly emphasizes the process of learning rather than the mere transmission of knowledge. Twenty-first century pedagogy encourages teachers and teacher candidates to become conscious facilitators of learning processes, rather than simple conveyors of information. In science teacher education — particularly for chemistry students — this shift presents a unique challenge: how to integrate deep disciplinary knowledge with the development of pedagogical and didactic competences.

Teaching chemistry is a complex activity that involves abstract concepts and experimentation while requiring constant attention to student motivation. Therefore, the lack of pedagogical training can significantly reduce the effectiveness of instruction (Bennett, Lubben & Hogarth, 2006). The pedagogy module aims to develop both learning and teaching awareness among teacher candidates: understanding how learning occurs and how it can be effectively facilitated for others.

Modern educational approaches — such as cooperative learning, project-based learning, and digital learning environments — are closely linked to the development of self-directed learning (Kálmán, 2013). In mastering these methods, students are encouraged to rethink their own learning techniques, reflect on their effectiveness, and consciously shape the dynamic interaction between teaching and learning.

Shulman's (1987) seminal theory of Pedagogical Content Knowledge (PCK) posits that effective teachers not only possess disciplinary knowledge but also know how to transform it didactically to make it comprehensible and learnable for students. He identified seven interrelated domains of teacher knowledge, encompassing instructional strategies, students' modes of thinking, and contextual awareness. PCK includes the use of analogies, illustrations, and explanations to address common misconceptions and adapt instruction to diverse learner needs.

From this perspective, the pedagogy module is not a supplementary component but a fundamental element of teacher education — one that integrates subject knowledge with pedagogical competence. Grossman (1990) later refined Shulman's model into a structure more suitable for empirical research, distinguishing four interconnected domains: Subject Matter Knowledge, General Pedagogical Knowledge, Pedagogical Content Knowledge, and Knowledge of Context. In Grossman's framework, PCK occupies a central position as it bridges disciplinary expertise, pedagogical understanding, and contextual factors. While Shulman's model incorporated broader theoretical and social dimensions, Grossman emphasized the practical interplay among these domains and the applied significance of PCK.

Research by Hattie (2012) further confirms that the most significant factor influencing teaching effectiveness is the teacher's ability to consciously guide learning processes and promote student understanding. Similarly, Feng et al. (2025), analyzing 82 studies on chemistry teachers' PCK published in SSCI journals, stress the importance of deliberately cultivating PCK in both teacher education and professional development—not merely through separate content or pedagogical training, but through their integration, considering students' prior knowledge, learning difficulties, and instructional approaches.

The development of teacher candidates' learning techniques is closely related to their metacognitive growth. According to Flavell (1979), *metacognition* refers to the awareness and regulation of one's own cognitive processes—a skill gradually developed during pedagogical training. In the methodology of teaching chemistry, this manifests not only in learning *what* to teach but also *how* to teach and how to reflect upon instructional decisions.

International literature underscores that one of the primary challenges of modern teacher education lies in bridging the gap between theoretical knowledge and practical application (Darling-Hammond, 2006). The pedagogy module provides the framework for this integration: it enables future teachers to interpret educational theories through the lens of their own learning experiences, thereby constructing a personal professional identity.

In summary, the literature highlights that the pedagogy module is not a formal requirement but a pivotal component of teacher education. It provides future teachers with the opportunity to interpret their disciplinary expertise within the dynamic process of teaching and learning while simultaneously enhancing their learning techniques, reflective capacity, and professional self-awareness.

Teaching Methods and Strategies in the Courses "Methodology of Chemistry Teaching" and "Didactics of Science"

Teaching chemistry presents a particular challenge: it involves abstraction, experimentation, and the continuous maintenance of motivation. The fundamental concepts of chemistry—such as *atom, molecule, ion; element, compound, mixture; physical change, chemical change, and amount of substance*—are not intuitive or naturally occurring ideas. Most students encounter them for the first time in school. The comprehension and internalization of these so-called *artificial concepts* are difficult precisely because they are not grounded in everyday experience (Szalay, 2015, p. 14).

Competence development in chemistry can only take place if we emphasize the understanding of these fundamental concepts that underpin chemical reasoning. When certain conceptual links are missing, students lose track of the logical structure of the subject and fail to grasp connections between topics. According to constructivist theories of learning (Nahalka, 1998), this may lead to a rejection of new knowledge: students who do not understand a concept often refuse to engage with it further. Consequently, they may resort to rote memorization and quickly forget what they have learned, or they become indifferent, convinced that chemistry is inherently incomprehensible.

At the undergraduate level, *Methodology of Chemistry Teaching* is taught in the second year, while *Didactics of Science* appears in the first year of the master's program. The main objective of these courses is to equip students with methods that can make the teaching of chemistry—often perceived as difficult and dry—clear, engaging, connected to everyday life, and interactive. Ninety percent of students report having missed such approaches during their own chemistry classes in school.

In both courses, the teaching–learning process is interactive and does not follow the traditional *two-hour lecture plus two-hour seminar* model. Typically, a short theoretical introduction is followed by group work or by a *jigsaw method* session, where students collaboratively process parts of the theoretical content. Each session ends with a plenary discussion and synthesis.

At the bachelor's level, after a detailed analysis of curricula and textbooks, students explore topics such as:

- **Using history in chemistry teaching** (brief, 2–5-minute contextual digressions about scientists' lives or the circumstances of discoveries to stimulate curiosity);
- **Experimentation in the classroom** (student micro-experiments, inquiry-based learning);
- **Creation of educational materials** (concept maps, learning cards, educational board games);
- **Design and analysis of competence-based worksheets** (pairing, sequencing, true/false, classification, association, deductive and inductive reasoning, reading comprehension).

In the master's program, the focus shifts toward **problem-solving instruction**, **teaching chemical concepts**, **identifying and addressing misconceptions**, **interdisciplinary connections of chemistry**, and **project-based learning**.

The overarching goal of these courses is for students to learn methods that render chemistry meaningful and enjoyable, making complex topics accessible and relevant. Exams are conducted in an *open-book* format, allowing students to use printed or digital materials. Final grades combine the exam score with assessments of homework and classroom participation. A further objective is to ensure that by the end of the semester, students are able to navigate and systematize the relevant literature.

A. The Expert Jigsaw Method

The *Expert Jigsaw* strategy has proven to be a highly effective tool for processing new content. For example, when discussing chemistry textbooks, each student group analyzes one section of a four-part article (e.g., the textbook's purpose, structure and didactic functions). After mastering their assigned section, "experts" reorganize into new groups to share insights and reconstruct the full content collaboratively.

The final product of this process is a poster synthesizing the article's key ideas. The class concludes with a plenary summary to ensure conceptual accuracy. Experience shows that this structure promotes deeper engagement: students are more likely to read and internalize the material when they are responsible for explaining it to peers, and they produce remarkably creative posters. Moreover, by participating in this process, they implicitly acquire the jigsaw method itself, which they may later apply in their own teaching.

B. Historical Perspectives in Chemistry Teaching

Sparking and maintaining students' interest is essential in chemistry education. Historical contexts serve as an excellent tool for this purpose, linking curricular content with stories of discovery, scientific debates, and the evolution of chemical thought. Beyond expanding students' general cultural knowledge (for instance, through etymological notes), such narratives highlight the cumulative nature of scientific knowledge and foster critical thinking by examining scientists' mistakes and the revision of outdated theories.

Historical vignettes can also form the basis of *discovery learning* and *inquiry-based science education*. It is important for pupils to understand that scientific progress is the result of collaborative efforts among researchers across nations—including Hungarian and Romanian scientists, who have made significant contributions to chemistry.

Students are required to prepare short historical summaries aligned with curricular topics, drawing on studies by Keglevich (2017, 2018), and present them in seminars using various digital platforms such as *Book Creator* or *Canva*.

C. Inquiry-Based Learning

Inquiry-based chemistry learning (IBL) is implemented using Szalay's (2016) collection of 24 inquiry worksheets, adapted to the national curriculum. This method is entirely new to most students, who have rarely encountered it in school. Initially, they struggle to understand the essence of independent investigation—they hesitate to make decisions, ask questions, or design research plans, fearing mistakes. Therefore, experiencing inquiry-based learning firsthand and analyzing both teacher and student roles in the process is essential.

As Korom (2016) explains, IBL does not necessarily require radical changes in teaching practices; familiar classroom experiments can be redesigned to provide greater autonomy in exploring phenomena. Since 2012, the *SAILS* project (Csapó et al., 2013) has documented the conditions and effectiveness of implementing IBL in science education.

D. Visualization in Chemistry Teaching

Concept maps and mind maps

While laboratory experiments are central to illustrating theory, simpler visual tools—such as periodic tables, charts, and flow diagrams—are also indispensable. In methodology seminars, students must construct mind or concept maps for specific topics and analyze examples created by school students. This helps reveal students' thought processes and potential misconceptions, while also confronting university students with their own misunderstandings.

Such exercises clarify how to structure information hierarchically and logically, and they encourage metacognitive reflection on learning organization.

Learning cards

Flashcards have become increasingly popular among international students, often supported by applications like *Anki* (from Japanese "anki," meaning memorization). The method, originally proposed by Sebastian Leitner in the 1970s, is based on *spaced repetition*: cards are reviewed at progressively increasing intervals depending on how well the learner recalls each item. Correct answers move a card to the next box; incorrect answers return it to the first one.

During courses in Analytical Chemistry, it was observed that students often struggled to recall key reaction schemes or essential theoretical principles. Introducing learning cards proved highly effective for mastering basic reactions and concepts. (Fig.1)

From a cognitive perspective, this aligns with the *Spaced Repetition System (SRS)*, which facilitates the transfer of information from short-term to long-term memory by periodically reactivating learned material.

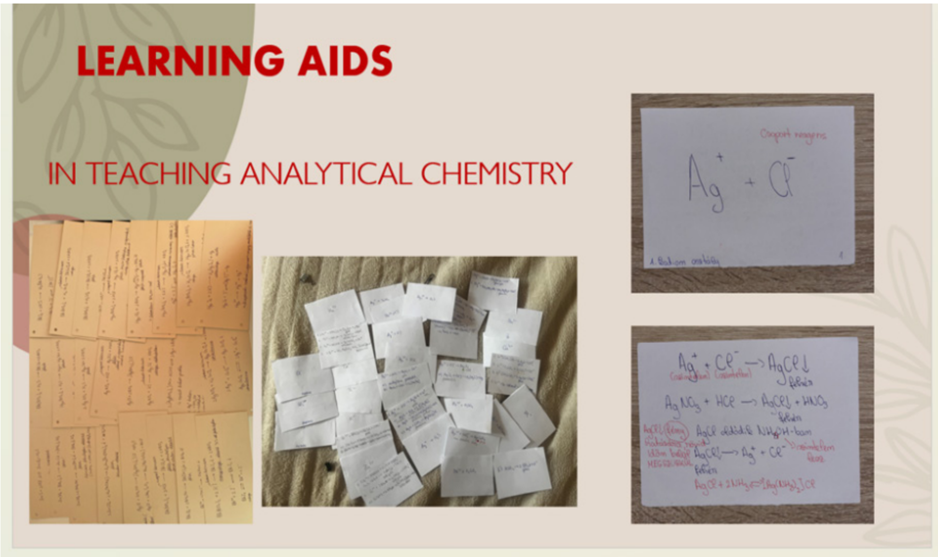

Figure 1. Flashcards made by students at Analytical Chemistry courses.

E. Chemical Misconceptions

The topic of *chemical misconceptions* provides a stimulating theme for methodology seminars. Numerous myths and misconceptions circulate in everyday discourse, often simplifying or distorting chemical phenomena. These misunderstandings may arise from gaps in scientific literacy, inaccurate media representations, or misinterpretations of everyday experiences.

The goal of chemistry education is to identify and correct such misconceptions while mapping students' conceptual frameworks. Through this process, teacher candidates not only learn how to teach specific concepts correctly and identify critical points of misunderstanding but also become aware of their own misconceptions and develop scientifically grounded thinking.

F. Microteaching and Pedagogical Practice

Self-evaluation and peer assessment are vital in establishing solid professional competence. These are implemented through *microteaching* sessions, in which students deliver short lessons to their peers following a school curriculum framework. Cooperative tasks also conclude with peer feedback. Learning to evaluate oneself and others fosters responsibility for learning, supports peers, and deepens understanding.

Kostiainen (2025) reports that teaching practice represents the most significant learning environment in teacher education, serving as the foundation for *meaningful learning*.

Master's students in methodology also participate in *peer mentoring* activities by correcting problem-solving exercises completed by undergraduates—a form of *learning by teaching*.

This *peer instruction* approach was originally developed by Eric Mazur at Harvard University in 1991. It is an interactive technique that integrates easily into traditional lectures, leveraging peer-to-peer dialogue to enhance conceptual understanding and problem-solving skills. The method is most effective when at least 80% of students are uncertain about a concept: brief paired discussions followed by class-wide reflection help clarify and consolidate understanding.

2. Purpose of the Study

The primary aim of this study is to explore how participation in the pedagogy module influences pre-service chemistry teachers' learning techniques and strategies. The research focuses on students' perceptions of pedagogical training as a space for developing autonomous, reflective, and effective learning habits.

The study addresses the following research questions:

1. Why do students choose the pedagogical module?
2. Which learning techniques and strategies do they prefer to use during learning?
3. How do chemistry students participating in teacher training perceive changes in their learning habits after attending pedagogical and methodological courses?
4. What kind of support would they need to make their learning more effective?

3. Research Methods

The study involved 28 pre-service chemistry teachers enrolled in Hungarian-language Chemistry and Chemical Engineering programmes at the Faculty of Chemistry and Chemical Engineering. Participation was voluntary. Most respondents were third-year undergraduate students, with an average age of 22.6 years.

Data were collected using an online questionnaire consisting of both closed and open-ended questions. The instrument examined students' learning habits, time-management strategies, preferred learning techniques, and perceptions of the pedagogy module. Items addressed note-taking practices, use of learning aids, changes in learning strategies compared to secondary school, and experiences with newly acquired learning methods.

Given the relatively small sample size, the study is exploratory in nature and aims to identify tendencies and patterns rather than produce generalisable conclusions.

4. Results

Among students enrolled in the Hungarian-language programs of Chemistry and Chemical Engineering, 70% choose to complete the pedagogy module. At the beginning of their studies, 40% of respondents expressed the hope that the methodology courses would help them become more professionally confident and improve their own learning techniques. 13.6% of the students intend to work exclusively as chemistry teachers, while 18% remain undecided regarding their future career path. The rest plan to pursue research or engineering careers but do not exclude the possibility of teaching. (Fig.2)

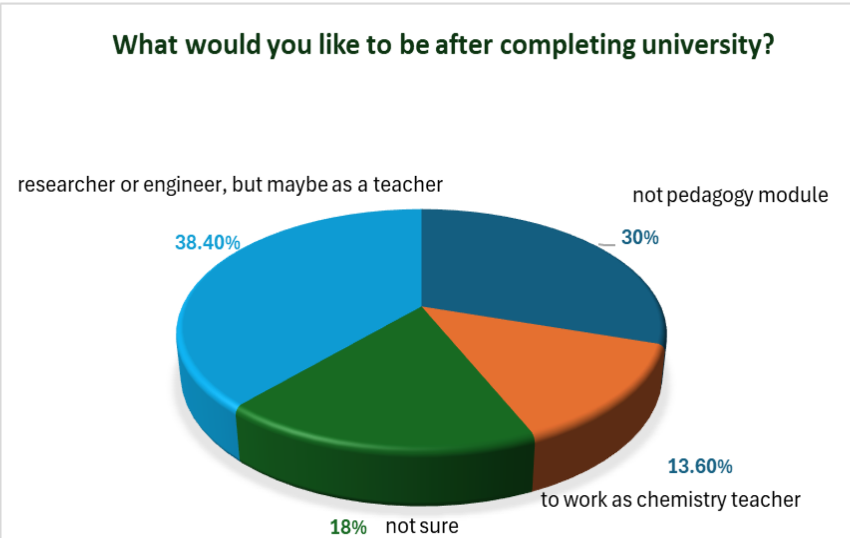

Figure 2. Statement by students enrolled in the Faculty of Chemistry and Chemical Engineering about what they would like to do after their university education

Approximately half of the respondents reported that their study habits had changed, either partially (40%) or completely (8%), compared to their earlier school experiences. Among the learning methods mentioned, 44% preferred handwritten notes, 9% used digital notes, 14% applied learning cards, and 7% used concept maps. 18% mentioned visual techniques such as drawing diagrams or sketches. (Fig.3)

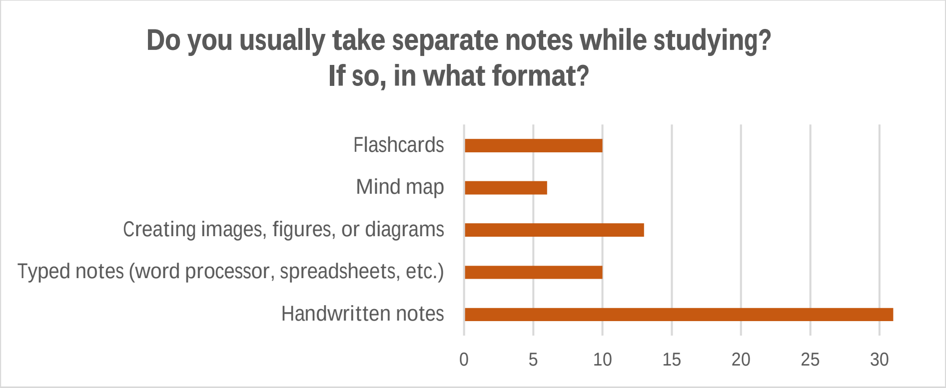

Figure 3. Learning by taking separate notes.

Most students reported studying primarily from printed materials, including personal notes and PowerPoint slides provided by instructors. Many also requested lecture notes from former students. Online courses and video materials were also frequently used to support learning. However, only a few students reported reading the recommended bibliography, and merely 4% actively searched for scientific papers related to the course topics. (Fig 4.)

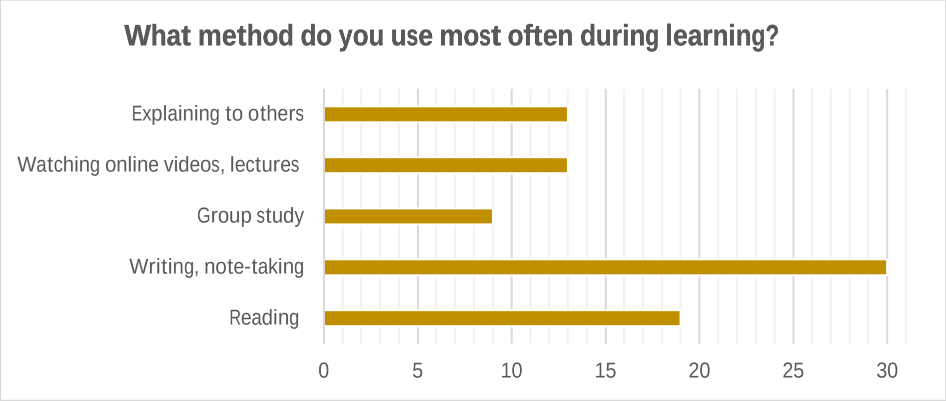

Figure 4. Learning methods.

Several respondents indicated that explaining material to others helped them consolidate their understanding—confirming the effectiveness of peer instruction and the “learning by teaching” approach.

Regarding the duration of study sessions, most students reported spending 2–3 hours per learning block, and some mentioned using the Pomodoro technique (25 minutes of focused study followed by a 5-minute break, with a longer break after four cycles).

When asked what hinders learning, 26% identified lack of motivation as the main obstacle—an issue that calls for serious reflection from educators. 58% wished for more practice exercises and self-assessment tests to prepare for exams, underscoring the need for formative assessment even at the university level.

Some students admitted that they were reluctant to ask questions during lectures and suggested implementing an anonymous “question box” at the end of classes, allowing them to submit questions that the teacher could address later.

Preferences regarding exam formats were diverse:

- 84% appreciated *midterm assessments* distributed throughout the semester,
- 70% favored *project work* and *open-book exams*,
- 16% preferred *oral exams*, while 52% would avoid them.

5. Discussion

Although the survey sample was small and preliminary, it underscores the importance of systematically examining students’ learning habits within each academic discipline (Fig.5). To meaningfully improve instructional methods, educators must not only evaluate teaching strategies but also analyze learning outcomes in parallel.

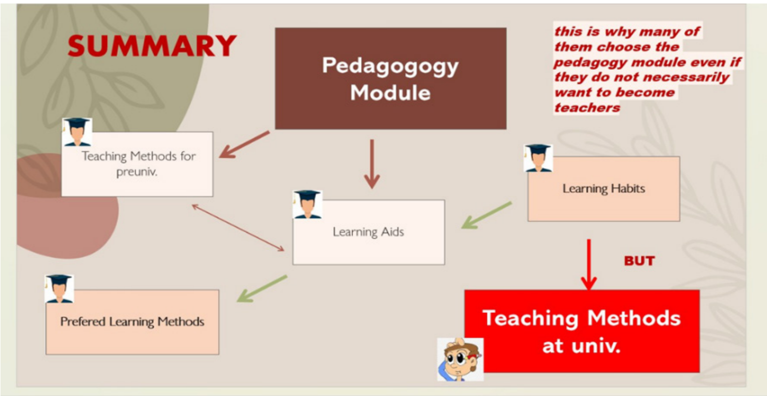

Figure 5. During the pedagogical module, students learn teaching and learning techniques and can improve their learning habits. The university can design its teaching methods according to the students' learning habits.

Moreover, students should receive explicit instruction in learning techniques to help them identify strategies that best suit their individual needs. This pedagogical support is especially relevant in science and engineering programs, where conceptual understanding and long-term knowledge retention are crucial.

The findings suggest that many students choose the pedagogy module even when they do not initially plan to become teachers. They are motivated by the opportunity to develop effective learning techniques, reflective thinking, and metacognitive awareness—skills that enhance both professional competence and lifelong learning.

6. Conclusion

This exploratory study indicates that pedagogical training in chemistry teacher education extends beyond formal qualification requirements. It is a transformative learning environment that enables students to reinterpret disciplinary knowledge through the dynamics of teaching and learning, to reflect on their own cognitive processes, and to cultivate the pedagogical content knowledge necessary for meaningful, learner-centered chemistry education.

BIBLIOGRAPHY

Bennett, J., Lubben, F., & Hogarth, S. (2006). Bringing science to life: A synthesis of the research evidence on the effects of context-based and STS approaches to science teaching. *Science Education, 91*(3), 347–370. https://doi.org/10.1002/sce.20197

Csapó, B., Csíkos, Cs., Korom, E., Harrison, C., Black, P., Finlayson, O., van Kampen, P., McLoughlin, E., & McCabe, D. (2013). *Report on the assessment frameworks and instruments for IBSE skills – Part A.* SAILS project. http://www.sails-project.eu/sites/default/files/d2.2.pdf

Feng, D., Lifan, Z., Junhao, Z., Bingxin, D., & Wanrong, D. (2025). *Chemistry teachers' pedagogical content knowledge: A review of empirical research published in SSCI journals from 1986 to 2024. Teaching and Teacher Education, 165*, 105109.

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive–developmental inquiry. *American Psychologist, 34*(10), 906–911. https://doi.org/10.1037/0003-066X.34.10.906

Grossman, P. L. (1990). *The Making of a Teacher: Teacher Knowledge and Teacher Education.* New York: Teachers College Press.

Hattie, J. (2012). *Visible Learning for Teachers: Maximizing Impact on Learning.* Routledge, London.

Kálmán, O. (2013). *Supporting Learning in Higher Education. Felsőoktatási Műhely*, 7, 15–22. (hun)

Keglevich, K. (2017). *The History of Chemistry in Chemistry Teaching. Magyar Kémikusok Lapja*, 12, 370–375. (hun) http://kemia.fazekas.hu/kemiatanaroknak/szakmai/mkl_2017_2018_kemiatort_kemia_tan.pdf

Keglevich, K. (2018). *The History of Chemistry in Chemistry Teaching. Magyar Kémikusok Lapja*, 9–14. DOI: 10.24364/MKL.2018.0.(73) (hun)

Kind, V. (2009). Pedagogical content knowledge in science education: Perspectives and potential for progress. *Studies in Science Education, 45*(2), 169–204.

Korom, E., Csapó, B., & Csíkos, Cs. (2016). The conditions for implementing inquiry-based learning in science education. *Iskolakultúra, 26*(3). DOI: 10.17543/ISKKULT.2016.3.30 (hun)

Kostiainen, E., & Pöysä-Tarhonen, J. (2025). Meaningful learning over the course of teacher education: Students' reflections. *Teaching and Teacher Education*, 105241.

Loughran, J., Berry, A., & Mulhall, P. (2012). *Understanding and Developing Science Teachers' Pedagogical Content Knowledge.* Rotterdam: Sense Publishers.

Magnusson, S., Krajcik, J., & Borko, H. (1999). Nature, sources, and development of pedagogical content knowledge for science teaching. In J. Gess-Newsome & N. Lederman (Eds.), *Examining Pedagogical Content Knowledge* (pp. 95–132). Dordrecht: Kluwer Academic Publishers.

Nahalka, I. (1998). Constructivist Pedagogy – A New Paradigm on the Horizon I–III. *Iskolakultúra*, 7(2–4). (hun)

Nahalka, I. (2002). *How Knowledge Develops in Children.* Budapest: National Textbook Publishing. (hun)

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4–14.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1–22.

Szalay, L. (Ed.). (2015). *Methodology of Teaching Chemistry.* Eötvös Loránd University, Budapest. (hun)

Szalay, L. (2016). *The Feasibility of Inquiry-Based Chemistry Teaching.* MTA–ELTE Research Group for Inquiry-Based Chemistry Teaching. https://ttomc.elte.hu/publications/90 (hun)