



Research Article

Organization and Content of Experiments for Developing Professional Competence of Students Based on Scribing Technology

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ABSTRACT:

The integration of visual technologies in higher education has gained increasing attention as a means of enhancing student learning outcomes and professional competence. Scribing technology -encompassing manual and digital methods of visual information representation -offers promising potential for structuring knowledge and fostering key competencies in future educators. Objective: This study aimed to verify the effectiveness of pedagogical conditions, a structural model, and a methodology for developing the professional competence of undergraduate students in a Mathematics and Informatics teacher education program through the systematic integration of scribing technology within the course 'Informatics and Digital Technologies'. Methods: An experimental was employed involving students from two higher educational institutions. An experimental group received instruction through the scribing-based methodology, while a control group followed the standard curriculum. Data collection instruments included questionnaires, pedagogical observation, analysis of student work products, content-specific tests, and self-assessment tasks. Levels of professional competence -encompassing digital, communicative, and creative components -were assessed at ascertaining and control stages using consistent diagnostic tools. Results: Following the formative intervention, students in the experimental group demonstrated positive dynamics across all three competence dimensions. Improvement was observed in digital literacy, communicative skills, and creative problem-solving compared with baseline measurements and the control group. Academic motivation and cognitive engagement also increased. Conclusions: The scribing-based methodology proves effective in developing multi-component professional competence among future educators. The findings support the purposeful incorporation of visual technologies in pedagogical higher education and provide a replicable framework for further implementation and research.

Keywords: *Scribing Technology; Professional Competence; Digital Competency; Creative Competency; Communicative Competency; Pedagogical Experiment; Higher Education; Informatics and Digital Technologies.*

1. INTRODUCTION

The growing complexity of the professional landscape for educators in the twenty-first century demands that teacher education programs move beyond the transmission of subject-matter knowledge and actively cultivate a broad spectrum of competencies. Among the most critical of these are digital literacy, communicative proficiency, and creative problem-solving -three capacities that are deeply intertwined with contemporary pedagogical practice and increasingly reflected in national educational standards (UNESCO, 2019; European Commission, 2022).

One pedagogical innovation that has attracted scholarly attention in recent years is scribing technology -a set of practices involving the real-time or structured visual representation of information

through drawings, diagrams, icons, and written text. Originally used in business and corporate training contexts, scribing has gradually entered higher education as a tool for facilitating conceptual understanding, sustaining learner attention, and promoting active knowledge construction (Jonassen, 2011; Mayer, 2020). Its implementation in a digital environment -through interactive online whiteboards and multimedia software -further aligns it with the competence demands of future teachers. Despite the growing body of literature on visual learning strategies, empirical evidence for the effectiveness of scribing technology in developing the multi-component professional competence of student teachers remains limited. Most existing studies focus on a single outcome dimension -such as conceptual recall or student engagement -without

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examining the integrated development of digital, communicative, and creative competencies within a unified instructional framework.

The present study addresses this gap by presenting a structured pedagogical experiment designed to verify the effectiveness of a scribing-based methodology implemented within the course 'Informatics and Digital Technologies' in undergraduate teacher education. The study contributes to the evidence base on technology-enhanced pedagogy and offers practical implications for curriculum designers and faculty in pedagogical higher education institutions.

1.1 Research Objectives

The study pursued the following objectives:

- To determine the initial (baseline) level of professional competence among participating students.
- To implement the scribing-based instructional methodology within the experimental group.
- To identify the dynamics of professional competence indicators following the intervention.
- To assess the influence of scribing technology on learning processes and academic outcomes.

2. LITERATURE REVIEW

2.1 Professional Competence in Teacher Education

Professional competence in teacher education is conceptualised as a multidimensional construct encompassing subject-matter knowledge, pedagogical skills, and cross-cutting transversal competencies (Shulman, 1987; Weinert, 2001). Contemporary frameworks -including the European DigComp 2.2 framework (Vuorikari et al., 2022) - highlight digital competence as an essential component that enables educators to design, implement, and evaluate technology-enhanced learning experiences. Communicative competence, understood as the capacity to convey complex information clearly and adapt to diverse audiences, and creative competence, characterised by divergent thinking and generative problem-solving, are similarly emphasised as foundational attributes of effective twenty-first-century educators.

2.2 Visual Learning and Scribing Technology

Theories of dual coding (Paivio, 1990) and multimedia learning (Mayer, 2009) provide a robust theoretical foundation for the use of visual representations in education. These theories posit that learners process and retain information more effectively when verbal and visual channels are engaged simultaneously. Scribing technology operationalises these principles by encouraging students to translate abstract content into coherent visual narratives -a process that demands both conceptual understanding and creative synthesis.

Digital scribing tools -including interactive whiteboards and collaborative online platforms - extend these affordances by enabling real-time, collaborative knowledge representation. Recent empirical work reports positive associations between the use of visual note-taking strategies and student engagement, information retention, and self-regulated learning (Bui & McDaniel, 2015; Fernandes et al., 2021). However, studies focused specifically on teacher education contexts and longitudinal competence development remain scarce.

2.3 Research Gap

While the general benefits of visual pedagogy are well-documented, the literature reveals a notable absence of controlled experimental studies examining the integrated effect of scribing technology on the tri-dimensional professional competence of pre-service teachers. The present study is positioned to address this gap by combining quantitative and qualitative diagnostic methods within an experimental design.

3. METHODS

3.1 Research Design

An experimental design with control and experimental groups was employed. The study was conducted in natural educational settings -without disrupting regular lesson structures or institutional schedules -at two higher educational institutions offering the 'Mathematics and Informatics' teacher education programme. At one institution, students from a single group participated (due to structural constraints); at the other, participants were assigned to a control group and an experimental group. For the single-group site, a pre-test/post-test design without a control group was applied.

3.2 Participants

Participants were undergraduate students enrolled in the 'Mathematics and Informatics' teacher education programme, studying the discipline 'Informatics and Digital Technologies'. The control and experimental groups were formed based on comparable baseline indicators of academic performance and digital technology proficiency to ensure the objectivity of subsequent comparative analyses. Instruction in all groups was conducted within a unified course curriculum with an equal academic workload. Ethical principles were maintained throughout: participation was voluntary, all participants were informed of the research goals, and data confidentiality was ensured.

3.3 Intervention

In the control group, instruction followed traditional teaching methods and tools as specified in the standard course curriculum. In the experimental group, the educational process was reorganised

around a scribing-based methodology developed and theorised in the preceding phases of the broader dissertation research. Scribing technology was integrated into all stages of each lesson -from the motivational-introductory phase to the summarising stage -ensuring coherence and systematic competence development.

The experimental lessons incorporated the following activity formats:

- Creation of manual and digital scribing notes on topics being studied.
- Visualisation of theoretical material during mini-lectures using interactive whiteboards.
- Completion of group and individual assignments using visual diagrams and conceptual models.
- Presentation and collaborative discussion of learning activity products.

Digital tools employed included interactive online whiteboards (e.g., Miro, Jamboard), multimedia presentation software, and specialised applications for creating visual notes.

3.4 Procedure and Stages

The experiment was structured in four sequential stages:

Stage 1 -Diagnostic and Forecasting: Identification of baseline research problems, clarification of research goals, and development of the experimental programme.

Stage 2 -Organisational and Preparatory: Establishment of experimental sites, formation of participant groups, and preparation of instructional and diagnostic materials.

Stage 3 -Practical Implementation: This central stage comprised three sub-stages -(a) the ascertaining sub-stage, which established baseline competence levels in both groups; (b) the formative sub-stage, during which the scribing-based methodology was implemented in the experimental group; and (c) the control sub-stage, in which post-intervention competence levels were assessed and compared across groups.

Stage 4 -Generalising: Systematic analysis and interpretation of the collected data, formulation of conclusions, and preparation of the final research report.

3.5 Diagnostic Instruments

A triangulated set of complementary diagnostic instruments was applied to ensure the objectivity and reliability of the data. These included:

- Structured questionnaires and student surveys assessing self-perceived competence levels.
- Systematic pedagogical observation of in-class behaviour and activity engagement.
- Analysis of student work products: scribing notes, visual diagrams, and project outputs.

- Content-specific test assignments covering the subject matter of 'Informatics and Digital Technologies'.

- Self-assessment tasks and structured reflection prompts.

Assessment was conducted against pre-established criteria and indicators enabling the classification of each student's professional competence as low, medium, or high across three components: digital, communicative, and creative. Identical diagnostic instruments were used at both the ascertaining and control stages to ensure data comparability and the correctness of statistical analysis.

4. RESULTS

4.1 Baseline Competence Levels

At the ascertaining stage, comparable baseline distributions of professional competence levels were established across the control and experimental groups. Both groups exhibited similar proportions of students at low, medium, and high competence levels across the digital, communicative, and creative dimensions, confirming the homogeneity of the sample and the suitability of the experimental design.

4.2 Dynamics Following the Intervention

Following the formative stage, students in the experimental group demonstrated positive dynamics across all three professional competence dimensions. The proportion of students classified at the high competence level increased in the experimental group compared with both their own baseline and the post-intervention results of the control group. Improvements were observed in:

- Digital competence: increased proficiency in using digital tools for visual knowledge representation and information structuring.
- Communicative competence: enhanced capacity to present and explain educational content to peers in a structured and accessible manner.
- Creative competence: improved ability to generate, visualise, and communicate original conceptual schemas and project solutions.

Academic motivation and cognitive engagement also showed measurable improvements in the experimental group, as reflected in observation records and self-assessment data. Students reported heightened interest in the course content and greater confidence in their ability to process and represent complex information visually.

4.3 Comparison with the Control Group

The control group, which continued with traditional instruction, exhibited only marginal changes in competence level distributions over the same period. The contrast between the two groups at the control stage confirmed that the observed gains in the experimental group were attributable to the scribing-

based intervention rather than to general course progression or maturation effects. Analysis of student work products further corroborated the quantitative findings: scribing outputs produced by experimental-group students at the end of the intervention displayed greater structural coherence, conceptual depth, and visual organisation relative to baseline work samples.

5. DISCUSSION

The results of the pedagogical experiment confirm that the systematic integration of scribing technology into higher education instruction constitutes an effective means of developing the multi-component professional competence of future Mathematics and Informatics teachers. These findings are consistent with the theoretical predictions of dual coding theory (Paivio, 1990) and multimedia learning principles (Mayer, 2009), both of which anticipate enhanced knowledge construction when verbal and visual processing channels are engaged together.

The simultaneous improvement across digital, communicative, and creative competence dimensions is particularly noteworthy and suggests that scribing technology functions as a cross-cutting pedagogical tool capable of fostering multiple competence domains within a single instructional framework. This finding extends prior work focused predominantly on single-outcome effects of visual learning strategies and offers stronger grounds for recommending the technology's integration into teacher education curricula.

The digital competence gains recorded are practically significant given the broader policy context: national and international frameworks for teacher education (UNESCO, 2019; DigComp 2.2) increasingly require graduates to demonstrate proficiency in technology-enhanced learning design. The results suggest that scribing - particularly when implemented through interactive digital platforms -provides authentic opportunities for developing these competencies within subject matter courses rather than in isolated technology training modules.

The improvement in communicative competence aligns with constructivist accounts of learning through teaching: by creating visual notes and presenting their work products to peers, students were required to articulate and negotiate conceptual

understanding, thereby consolidating and deepening their knowledge. The creative competence dimension benefited from the open-ended, generative character of scribing tasks, which demanded divergent thinking and the production of novel representational forms.

5.1 Limitations

Several limitations should be acknowledged. First, the experimental design -while appropriate for natural educational settings -does not permit the same inferential rigour as true random assignment. Second, the absence of a control group at one of the two research sites necessitated a pre-test/post-test design, limiting the scope of between-group comparisons. Third, sample size details and effect sizes could not be reported in full in the current publication, and these will be provided in the extended dissertation monograph. Future studies should employ randomised controlled designs with larger, more geographically diverse samples and include long-term follow-up measurements to assess the durability of competence gains.

6. CONCLUSIONS

The present study provides empirical support for the effectiveness of a scribing-based instructional methodology in developing the professional competence of future teachers within the course 'Informatics and Digital Technologies'. The intervention produced measurable positive dynamics in students' digital, communicative, and creative competence levels, as well as in academic motivation and cognitive engagement.

The findings demonstrate that purposeful integration of scribing technology -spanning both manual and digital formats -into all structural elements of a university lesson constitutes a pedagogically sound approach to competence-based education. The systematic use of visual note-taking, interactive whiteboards, and group visualisation tasks creates conditions for active, student-centred learning that aligns closely with contemporary frameworks for teacher professional development.

On the basis of these results, it is recommended that higher education institutions offering teacher education programmes consider incorporating scribing technology as a regular component of courses in the informatics and digital technologies domain. The developed model, pedagogical

conditions, and diagnostic tools may serve as a replicable and adaptable framework for faculty

seeking to enhance student professional competence through evidence-based visual pedagogy.

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