

THE METHODOLOGICAL SYSTEM OF USING ADAPTIVE CURRICULA AND VIRTUAL LABORATORIES IN TEACHING THE SUBJECT “INFORMATICS AND ITS TEACHING METHODOLOGY”

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Abstract. *The article develops a methodological system for the use of adaptive curricula and virtual laboratories in teaching the subject “Informatics and its Teaching Methodology” to future primary school teachers. The author proceeds from the fact that student groups in pedagogical faculties are exceptionally heterogeneous in their initial informatic preparation, and that a single sequence of instruction therefore leaves part of the group without support and another part without challenge. Adaptivity is treated not as an automated selection of exercises but as a pedagogically governed variation of four parameters — the sequence of content, the level of task difficulty, the volume of instructional guidance and the form of feedback. The virtual laboratory is treated as an environment of professional trial in which the student models the behaviour of a primary school pupil, tests methodological decisions and observes their consequences without risk to real children. The article defines the target, content, procedural, technological and diagnostic components of the system, formulates the conditions of its functioning, and describes the sequence of its implementation and the criteria of its effectiveness.*

Keywords: *adaptive learning, adaptive curriculum, virtual laboratory, informatics teaching methodology, future primary school teachers, differentiation, learning analytics, methodological system, formative assessment.*

Introduction

The subject “Informatics and its Teaching Methodology” is taught to students whose initial preparation differs more sharply than in almost any other course of the faculty. Within one group there are students who completed specialised informatics classes at school and students whose experience of computing is limited to a mobile telephone. This heterogeneity is a stable characteristic of the contingent rather than a temporary defect of recruitment, and it makes uniform instruction inefficient at both ends: the prepared student repeats what is mastered, the unprepared one accumulates gaps that later block the methodological part of the course.

At the same time, the methodological part of the subject requires practice of a kind that a lecture hall cannot provide. A future teacher must learn to predict how a seven-year-old will read an instruction, where an algorithmic task will produce a typical error, and how to rebuild an explanation the class has not followed. Such competence is formed only in trial, and trial in a real class is available in limited quantity and at a pedagogical cost to the pupils involved.

Two instruments correspond directly to these problems: adaptive curricula answer the heterogeneity of preparation by varying each student's path through the content, and virtual laboratories answer the shortage of practice by providing a modelled environment in which methodological decisions can be tested repeatedly. The purpose of the article is to substantiate a methodological system in which the two instruments operate as parts of a single design, and to determine the conditions under which it produces professional rather than merely technical results.

Literature review

Research on adaptive instruction begins from the classical finding that individualised tutoring produces gains far above conventional group teaching, which set the problem of reproducing tutorial conditions by scalable means [7]. Comparative evaluations later established that well-designed intelligent tutoring systems approach, without equalling, the effectiveness of human tutors, and that their advantage derives from the granularity of feedback rather than from technology as such [1]. The apparatus of student modelling, built around the tracing of mastery across knowledge components, supplied the means of deciding what a learner should receive next [8].

Later work has clarified what may usefully be adapted. A taxonomy of adaptivity distinguishes adaptation of content, sequence, scaffolding and assessment, and warns that adapting superficial features such as presentation style yields little whereas adapting difficulty and guidance yields much [5]. Reviews of learner characteristics agree: prior knowledge is the most productive basis for adaptation, while trait variables such as learning style have not proved instructionally useful [9]. Systematic reviews also note the weakness of the evidence base, dominated by short interventions and non-equivalent comparison groups [15], and caution against treating commercial adaptive platforms as pedagogically neutral [16].

Research on virtual laboratories has followed a comparable trajectory. Early comparative reviews of hands-on, simulated and remote laboratories showed that the three formats support different outcomes and are not interchangeable [2]. A large synthesis found that non-traditional formats equal or exceed traditional ones on most measured outcomes, particularly conceptual understanding [3], while experimental work showed that virtual manipulation can outperform physical manipulation when it makes invisible relations visible and removes procedural noise [10].

The productive question is therefore not which format is superior but how physical and virtual work should be combined within one instructional sequence [4], and the value of a virtual laboratory depends on the tasks surrounding it rather than on the fidelity of the simulation [11].

Finally, both instruments are constrained by what is known about the architecture of learning: cognitive load theory establishes that guidance must be reduced as expertise grows and that one and the same task may be productive for one student and overwhelming for another [12]; the principles of multimedia learning define how a laboratory interface should present information if it is not to consume the resources the task requires [13]; and the zone of proximal development supplies the criterion for the level at which adaptation should aim [14].

Methods

The study is theoretical and design-oriented. It combines analysis of scholarly sources on adaptive learning and virtual laboratories, examination of the current syllabus and methodological support of the subject, and pedagogical modelling of the system's components. Each component was derived by identifying a professional deficiency observed in the preparation of future primary school teachers and determining the instrument, the type of task and the form of assessment capable of removing it. Individual elements were tested in seminar sessions and refined on the basis of students' results and the observations of methodologists.

Results and discussion

Structure of the methodological system. The system comprises five components, shown in the table below. Their separation is not formal: each answers a distinct design question and each has a characteristic failure mode when left implicit. The target component prevents adaptation towards trivial goals, the content component determines what may legitimately vary, the procedural component defines the activity of the student, the technological component supplies the instruments, and the diagnostic component supplies the data without which adaptation becomes arbitrary.

Component	Content	Realisation in the subject
Target	Integrated informatic and methodological outcomes, differentiated by depth but not by scope	Competence matrix with basic, intermediate and advanced levels for each unit
Content	Content divided into invariant core and variable extension; knowledge components with prerequisite links	Modular map of the course with prerequisites made explicit
Procedural	Individual trajectory, small-group methodological design, virtual laboratory trial, reflection	Cycle: diagnosis – trajectory – trial – feedback – revision
Technological	Adaptive platform, block-based programming environment, virtual laboratory of the lesson, learning analytics	Integrated digital workplace of the student
Diagnostic	Entry, formative and summative diagnosis of both informatic and methodological competence	Task bank calibrated by difficulty and by knowledge component

The adaptive curriculum component. Adaptivity in the proposed system varies four parameters and no others. The first is the sequence of study: a student who has demonstrated mastery of a knowledge component at entry proceeds directly to its methodological application, while a student who has not receives a preparatory block first. The second is difficulty: each outcome is supported by tasks of three calibrated levels, and transition between them is governed by demonstrated performance rather than elapsed time. The third is the volume of guidance: worked examples and step-by-step prompts are given in full at the outset and withdrawn progressively as accuracy grows, in accordance with the expertise reversal effect [12]. The fourth is the form of feedback: automated correctness feedback serves algorithmic and operational tasks, while methodological products receive rubric-based expert feedback that no automatic mechanism replaces [6].

Two restrictions are essential. First, adaptation applies to the path and not to the destination: every student reaches the same set of professional outcomes, and differentiation concerns the route, the pace and the degree of support. Second, adaptation is governed by evidence of prior knowledge and current performance, and not by declared preferences or presumed styles, for which no instructional benefit has been established [9].

Without them an adaptive course degenerates into a reduced curriculum for weaker students or into superficial personalisation.

The virtual laboratory component. In the subject under discussion, the virtual laboratory has a dual character, and this duality is its principal methodological value. In the first it is a laboratory of informatics: the student assembles algorithms, traces their execution, observes the effect of an error and manipulates representations of processes invisible in ordinary practice. In the second it is a laboratory of teaching: the student works with a model of a primary class, formulates an instruction as it would be given to seven-year-olds, and observes the modelled responses, including the misconceptions typical of that age.

The second function is decisive for a methodology course. It lets the future teacher encounter the characteristic errors of primary pupils — reading a repetition as a single action, confusing an instruction with its result, taking a conditional literally — in a form that can be studied and repeated. Four types of laboratory task are distinguished: observational, in which the student diagnoses the cause of a modelled pupil's error; design, in which an explanation is constructed and tested against the model; comparative, in which two methodological variants are tried and contrasted; and corrective, in which a defective lesson fragment is rebuilt. Since virtual and physical practice are complementary rather than competing [4; 10], every laboratory cycle ends in a real trial with pupils during teaching practice, and the discrepancy between modelled and real outcomes becomes itself an object of methodological analysis.

Integration of the two instruments. The instruments are joined by a single flow of diagnostic data. Laboratory results identify the knowledge component in which a methodological decision failed, and the adaptive curriculum returns the corresponding content in an appropriate form; mastery certified by the adaptive component in turn opens access to laboratory tasks of higher complexity.

This closed loop distinguishes a methodological system from a combination of digital tools: the adaptive component without trial produces knowledge that is not applied, and the laboratory without adaptation produces trial for which some students are unprepared.

Implementation and conditions

Implementation proceeds in four stages. The preparatory stage establishes the map of knowledge components with their prerequisite links and calibrates the task bank. The diagnostic stage determines each student's entry level in both the informatic and the methodological dimension.

The main stage realises the cycle of diagnosis, trajectory, trial, feedback and revision across the units of the course, and the corrective stage analyses the accumulated data to revise task calibration and transition thresholds for the next cohort.

Three conditions determine whether the system functions as intended. The first is the quality of the task bank: adaptation is only as good as the calibration of its items, and an uncalibrated bank produces confident but arbitrary decisions.

The second is the preparedness of the instructor, who must interpret analytical data pedagogically and retain the authority to override an automated recommendation. The third is transparency: a student who does not understand why a task has been assigned cannot regulate his or her own learning, and the system then forms dependence rather than autonomy.

Expected results and criteria

The effectiveness of the system is assessed by four criteria. The criterion of levelling concerns the reduction of dispersion within the group without lowering the ceiling of achievement.

The criterion of transfer concerns the ability to apply the informatic knowledge acquired in the design of a primary lesson. The criterion of diagnostic accuracy concerns the correctness with which students identify the causes of pupils' errors, measured against expert judgement. The criterion of autonomy concerns the students' capacity to plan their own further study without external prompting. Together they establish whether the system has produced professional competence or only an increase in completed exercises — a distinction the internal metrics of adaptive platforms characteristically obscure [16].

Conclusion

Adaptive curricula and virtual laboratories address two different and equally real deficiencies in the teaching of the subject "Informatics and its Teaching Methodology": the heterogeneity of the students' initial preparation and the shortage of professional trial. Taken separately each yields limited results; joined by a common flow of diagnostic data they reinforce one another, since adaptation prepares the student for trial and trial supplies the evidence on which further adaptation rests.

The five-component system proposed in the article, together with the four parameters of adaptation, the four types of laboratory task and the four stages of implementation, constitutes a working basis for the reconstruction of the software and methodological support of the subject. Its realisation requires a calibrated task bank, a methodologically prepared instructor and transparency of decisions for the student. Further research should provide experimental verification of the system across successive cohorts and should establish the optimal proportion between virtual and real professional trial in the preparation of primary school teachers.

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