DESIGNING MULTI-LEVEL CREATIVE INQUIRY TASKS IN A VIRTUAL PEDAGOGICAL ENVIRONMENT FOR FUTURE TEACHERS

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Abstract. This thesis examines the design of multi-level creative inquiry tasks in a virtual pedagogical environment for preparing future teachers. The idea is based on the need to use virtual modeling not only as a visual support, but also as a didactic space where students gradually move from guided observation to independent pedagogical design. The proposed task structure includes four interconnected levels: reproductive orientation, analytical exploration, partial inquiry and creative pedagogical transformation. Each level increases the learner's responsibility, supports model-based reasoning, and connects digital activity with future teaching practice. The thesis emphasizes that creative thinking develops more effectively when virtual tools are combined with problem situations, hypothesis formulation, evidence collection, collaborative explanation, reflective questions and criteria-based assessment.

Keywords: creative inquiry tasks, virtual pedagogical environment, teacher education, virtual modeling, pedagogical reflection, digital pedagogy

Digital transformation has expanded the possibilities of higher pedagogical education. Virtual laboratories, interactive models, 2D and 3D simulations and digital assessment tools allow teacher educators to organize learning in a more visual, flexible and inquiry-oriented form. However, the effectiveness of a virtual pedagogical environment depends not only on the attractiveness of the software. Its real pedagogical value is determined by the quality of the tasks performed by students. If a simulation is used only for demonstration, future teachers may remain passive observers. If the same simulation is organized through a system of questions, actions and reflection, it becomes a professional training space.

Future teachers need to learn how to create learning experiences, not simply how to use digital materials. They should understand how a task directs attention, creates a problem, encourages comparison, stimulates questions and leads learners toward an independent conclusion. For this reason, the development of creative thinking should be closely connected with task design. A task that is too simple only forms mechanical repetition, while an overly difficult task may cause confusion and dependence on the instructor. A multi-level sequence makes it possible to increase independence gradually and to maintain a balance between support and creativity.

The proposed approach interprets creative inquiry as a sequence of learning actions: observing a model, analyzing visible changes, formulating a hypothesis, testing it through parameter changes, interpreting the result, transforming the result into a pedagogical idea and evaluating the process through reflection. Such a sequence is especially important in pre-service teacher preparation because students develop two competences at the same time. First, they deepen their understanding of the modeled content. Second, they learn to transform this content into teachable material for future learners.

The first level of the task sequence is reproductive orientation. At this level, students become familiar with the virtual model, its interface, terminology, variables and basic sequence of actions. They may be asked to identify the main elements of the model, follow a short instruction, observe a phenomenon and describe what happens when one parameter changes. The main aim is not to limit students to reproduction, but to prepare them for deeper inquiry. Without initial orientation, students may focus on technical details and fail to notice the educational meaning of the model. Assessment at this stage can include simple indicators: the student understands the instruction, uses the model correctly, records an observation accurately and explains the observed action in his or her own words.

The second level is analytical exploration. Here students compare model scenarios, identify relationships between variables and explain why one result differs from another. They may run two or three simulations, create a small comparative table, describe causal links or determine which condition influences the result most strongly. This level moves learners from description to explanation. For future teachers, analytical exploration should also include didactic questions: Which part of the model is easier for learners to understand? Which visual element may cause difficulty? What guiding question can help pupils see the main relationship? Thus, the student begins to think not only as a learner, but also as a future organizer of learning.

The third level is partial inquiry. At this stage, students receive a problem situation but not a complete algorithm for solving it. They formulate a hypothesis, choose relevant parameters, test their assumption and interpret the result. The instructor still provides boundaries, but the path of investigation becomes more independent. This level is important for creative thinking because it trains students to work with uncertainty. If the result does not confirm the original hypothesis, the student should revise the explanation, not simply search for the expected answer. Such experience is pedagogically valuable because future teachers must be able to guide learners through mistakes, alternative interpretations and evidence-based conclusions.

The fourth level is creative pedagogical transformation. At this level, the virtual model becomes a resource for designing a teaching product. Students may prepare a mini-lesson, a problem-based activity, a reflective worksheet, a project idea, an assessment rubric or a digital demonstration plan. The focus shifts from understanding the model to adapting it for pedagogical purposes. This level integrates subject knowledge, digital competence, didactic planning and professional creativity. The designed task can be evaluated through several questions: Does it include a real problem situation? Does it require evidence rather than memorization? Are the instructions clear for learners? Does it allow more than one solution? Does it contain reflection or assessment criteria?

The implementation of multi-level creative inquiry tasks can be organized through several connected steps. First, the teacher educator diagnoses students' prior knowledge, digital readiness and possible difficulties. Second, tasks are sequenced from orientation to analysis, from analysis to inquiry and from inquiry to pedagogical design. Third, students perform the tasks in the virtual environment, while the instructor acts as a facilitator rather than the only source of answers. Fourth, students present their observations and compare interpretations in pairs or groups. Fifth, they complete a short reflective note explaining what they discovered, which difficulty appeared, how the model can be used in a future lesson and what they would change in the task design.

In this process, the role of the teacher educator becomes multidimensional. As a designer, the instructor selects simulations, prepares problem situations and aligns assessment criteria with learning outcomes. As a facilitator, he or she asks clarifying questions, directs attention to evidence and encourages students to justify their decisions. As an evaluator, the instructor assesses not only the final answer, but also the process of hypothesis building, evidence collection, explanation, collaboration and reflection. As a mentor, the instructor helps students connect virtual experience with future professional practice. This balance is necessary because excessive control makes the task reproductive, while insufficient guidance may reduce the quality of inquiry.

Assessment in a virtual pedagogical environment should be transparent and criterion-based. General marks do not show how creative inquiry develops. More useful criteria include clarity of problem understanding, purposeful use of the virtual model, quality of hypothesis, evidence collection, depth of explanation, originality of pedagogical transformation, feasibility of the designed task and reflective self-evaluation. These criteria can be described at three levels. At the initial level, students complete the action with guidance and give a simple explanation. At the intermediate level, they work more independently and support conclusions with evidence. At the advanced level, they transfer the action to a new situation, design a pedagogical product, consider learner difficulties and justify decisions convincingly.

For practical organization, each task card may contain four short elements: the problem question, the digital action, the expected evidence and the reflective prompt. The problem question gives meaning to the simulation; the digital action tells students what to manipulate or compare; the expected evidence reminds them that every conclusion should be supported by observation; and the reflective prompt connects the task with teaching practice. Such a card is concise, but it prevents the task from becoming a random technical exercise. It also helps students understand the difference between seeing an animation and using a model for pedagogical reasoning.

The multi-level sequence may be used during lectures, practical classes or independent work. In a lecture, the instructor can demonstrate the first level and invite students to predict the result before showing the simulation. In a practical class, students can complete analytical and partial inquiry tasks in small groups. During independent work, they can prepare creative transformation products, such as lesson fragments or reflective worksheets. This distribution makes the approach realistic for higher education because it does not require replacing the whole curriculum. It enriches existing topics with a more active and professionally oriented task structure.

Another important condition is the connection between individual and collaborative activity. Individual work helps students formulate their own hypothesis and take responsibility for their reasoning. Group discussion helps them compare interpretations, notice weak evidence and improve explanations. When students defend their designed pedagogical tasks before peers, they practice professional communication. This is useful for future teachers because pedagogical creativity is not only an internal cognitive process; it is also expressed through dialogue, explanation, adaptation and the ability to justify decisions to learners and colleagues.

The proposed framework differs from a simple recommendation to use virtual laboratories. It shows that the pedagogical value of a virtual environment is created by the structure of activity inside it. A simulation becomes a developmental tool when it is connected with inquiry, explanation, design and reflection. The four-level sequence also prevents monotony. If all tasks are based only on observation, students may become passive. If all tasks are completely open-ended, some learners may lose orientation. A gradual structure supports both accessibility and creativity.

The proposed task structure also supports differentiation. Students with lower digital readiness may begin with guided observation and simple analytical comparisons, while stronger students may move faster toward partial inquiry or creative transformation. This is important in pedagogical institutes because groups are often heterogeneous: some students confidently use digital tools, whereas others need gradual orientation. Differentiated task cards make it possible to preserve a common learning aim while varying the level of independence. As a result, virtual modeling becomes accessible for all students and challenging for those who are ready for deeper pedagogical design.

The content of tasks should also be connected with assessment from the beginning. If students know that they will be evaluated according to the quality of their hypothesis, evidence, explanation, transformation and reflection, they pay attention to the reasoning process rather than only the final answer. This changes the culture of learning. Students begin to ask why a certain result appeared, what evidence confirms it, how it can be explained to another learner and how the task can be improved. Such questions are directly related to professional teacher thinking.

Multi-level creative inquiry tasks are useful not only for developing separate digital skills, but also for forming an integrated professional position. Future teachers learn to see digital tools as pedagogical instruments. They understand that a model is not valuable because it is animated, but because it can make a hidden relationship visible, create a problem situation, stimulate discussion and help learners justify conclusions. This view protects teacher education from superficial technologization and strengthens the connection between innovation and didactic purpose.

The framework can be adapted to different subjects. Although the dissertation background uses molecular physics as an applied didactic field, the logic of reproductive orientation, analytical exploration, partial inquiry and creative pedagogical transformation can be used in biology, chemistry, geography, technology, engineering and other disciplines where modeling and visualization are meaningful. What changes is the subject content; the pedagogical logic remains stable.

In conclusion, a virtual pedagogical environment can support the development of creative thinking in future teachers when it is organized through multi-level creative inquiry tasks. Such tasks turn digital interaction into a professional learning process in which students observe, compare, hypothesize, test, explain, design and reflect. The success of this approach depends on thoughtful task sequencing, facilitator support, collaborative interpretation and clear assessment criteria. When these elements are combined, virtual modeling contributes to creative thinking, digital-pedagogical competence, evidence-based reasoning and professional reflection. Therefore, multi-level task design should be considered an essential component of modern teacher preparation in a digital educational environment.

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