

Mastering The Cell Topic In 7th Grade Through Activity-Based Tasks

Asrorova Odinaoy

Biology teacher at the Presidential School in Bukhara, Uzbekistan

Received: 09 June 2025; **Accepted:** 05 July 2025; **Published:** 30 August 2025

Abstract: This article proposes and evaluates a practical methodology for teaching the middle-school cell unit through activity-based tasks that foreground inquiry, modeling, and purposeful talk. The approach is grounded in constructivist and sociocultural theories of learning, the 5E instructional model, and contemporary evidence on formative assessment. A teaching sequence for 7th grade was designed around authentic problems that require students to observe cells under a microscope, build and revise physical and diagrammatic models of organelles, investigate osmosis with everyday materials, and justify claims with evidence in written and oral formats. The methodology was implemented across six lessons totaling approximately 270–300 minutes in ordinary school conditions. A pre-/post design with a concept inventory, performance rubrics for practices such as planning investigations and interpreting data, and short reflective prompts was used to estimate learning gains and to trace conceptual change. Results show large improvements in recognition of the cell as the basic unit of life, structure–function reasoning about organelles, and the ability to apply diffusion and osmosis ideas to new contexts. Students’ written arguments became more mechanistic and less descriptive, while classroom discourse shifted toward student-generated questions and evidence-based explanations. The article discusses design principles for sequencing activity-based tasks, aligning representations across physical models, drawings, and micrographs, and using formative assessment to surface and respond to misconceptions without interrupting inquiry. Recommendations are offered for adapting the sequence to resource-constrained settings and for extending the approach into genetics and physiology topics in grades 8–9.

Keywords: Activity-based learning; 5E model; cell biology; middle school; inquiry; modeling; formative assessment; osmosis

Introduction: For many students, the cell is the first abstract biological system they must reason about at multiple levels of organization. Its intangible scale, specialized vocabulary, and unfamiliar tools make the topic prone to persistent misconceptions: learners often treat cells as static bags of parts, confuse plant and animal structures, or believe that only animals have cells. Conventional teaching can exacerbate the problem when it is dominated by vocabulary memorization, decontextualized diagrams, and teacher exposition. In contrast, activity-based pedagogy invites students to engage in the epistemic practices of science—posing questions, observing, modeling, arguing from evidence—so that concepts emerge as solutions to meaningful problems. Research on inquiry-oriented instruction and visible learning suggests that well-scaffolded practical work, conceptually focused

models, and frequent, low-stakes feedback yield higher retention and transfer than presentation-first approaches, especially in topics with dense representational demands such as the cell.

The challenge for teachers is to translate general principles into lesson-level moves that fit the time and resource constraints of a typical 7th-grade classroom. Activity-based lessons must be safe, feasible with inexpensive materials, and coherent across days so that new representations build on prior ones rather than proliferate into disconnected artifacts. The present study addresses this challenge by designing and testing a compact sequence of tasks that organizes the cell unit around three questions: what counts as evidence that living things are cellular, how do internal structures support life functions, and why does water move across cell boundaries? By embedding each question in

observable activity—microscopy, modeling, and osmosis investigations—the sequence aims to anchor abstract terms in material experience while cultivating explanatory habits of mind.

The study aims to develop, implement, and evaluate a methodology for mastering the cell topic in 7th grade through activity-based tasks. Specifically, it seeks to determine whether a coherent sequence of inquiry and modeling activities can improve conceptual understanding of cell structure and function, strengthen students' ability to interpret micrographs and construct mechanistic explanations, and promote durable understanding of diffusion and osmosis that transfers to novel situations. A secondary aim is to document classroom conditions and assessment tools that make the approach practical for teachers, including rubrics that capture growth in scientific practices and formative strategies for addressing common misconceptions.

The teaching sequence was designed with the 5E model—Engage, Explore, Explain, Elaborate, Evaluate—so that activities develop ideas incrementally. Lessons took place in a mixed-ability 7th-grade cohort over two weeks, with three 45-minute periods per week. Materials were limited to school microscopes with 100× and 400× magnification, prepared slides of onion epidermis and elodea leaves, cotton swabs and methylene blue for cheek cells where policy permitted, plastic cups, potatoes or cucumbers, salt and sugar solutions of varying concentrations, digital scales, graph paper, basic craft supplies for physical cell models, and printed micrographs. The sequence opened with a discrepant event in which students compared micrographs of cork, onion, and newspaper fibers to surface the idea that living materials have cellular organization while non-living materials do not, establishing a need for a definition and criteria. Students then learned safe handling, focusing, and drawing techniques for microscopy; every observation produced a scaled drawing with labels and a short caption that stated what the evidence suggested about the structure or the function of the cells observed.

Modeling activities began with a simple clay-and-cardboard construction of plant and animal cells and continued with revisions prompted by new micrograph evidence. Rather than assigning organelles as a list of names, the teacher introduced structure–function problems—how do cells maintain boundaries, harvest energy, and synthesize outputs—and asked students to propose and justify which components must be present to solve each problem. This practice deliberately delayed canonical labels for a lesson so that students experienced models as explanatory tools rather than as

decorative replicas. To develop an operational understanding of osmosis, students cut equal-sized potato strips, measured mass and length, and submerged them in unlabeled cups containing water or solutions at different concentrations. After twenty to forty minutes, they reweighed the strips, observed turgor changes, calculated percentage mass change, and collectively interpreted results to decide which cups contained hypertonic or hypotonic solutions. In classrooms without scales, teachers substituted qualitative measures such as curvature and firmness ratings, and reinforced reasoning with elodea leaf plasmolysis under the microscope.

Assessment combined a content-focused concept inventory aligned to the unit's big ideas with performance-based rubrics derived from national and international frameworks for scientific practices. The concept inventory included multiple-choice items with distractors that reflected common misconceptions about cell walls versus membranes, the universality of cells, the role of the nucleus, and the direction of water movement relative to solute concentration. Short constructed responses required students to interpret novel micrographs and to argue from evidence about whether an image showed a plant or animal cell and why. Rubrics scored the planning of investigations, data representation and interpretation, model construction and revision, and the quality of written claims with evidence and reasoning. Pre- and post- tests framed the two-week sequence. The teacher embedded formative assessment in every lesson through exit slips, brief oral conferences during lab work, and public synthesis on whiteboards where groups shared measurements, graphed results by hand, and compared interpretations.

To gauge practicality and reliability, the study documented time on task, the frequency of equipment issues, and the inter-rater consistency of rubric scores across two teachers. Teachers captured anonymized student talk using audio snippets during whole-class discussions to analyze the proportion of explanation versus description and the presence of causal language. While the design did not include a formal comparison group, teachers contrasted results with data from the previous year's cohort taught with a presentation-heavy method, using common questions where available. Ethical safeguards included anonymization, opt-out consent procedures approved by the school, and adherence to safety protocols for chemical solutions and cheek-cell sampling.

The activity-based sequence produced clear gains in students' conceptual understanding and scientific practices. Pre-test responses showed that many students initially believed that plant cells are defined by

chloroplasts and that animal cells lack membranes or rigid boundaries. A sizable minority assumed that osmosis is the movement of solute rather than solvent, and several equated the nucleus with the “brain” that “controls everything,” a metaphor that discouraged mechanistic reasoning. Post-test data revealed substantial reductions in these misconceptions. Students correctly identified the membrane as a universal boundary distinguishing all cells and recognized the cell wall as an additional structure in plants. They explained the nucleus in terms of information storage and gene expression rather than personified control. When interpreting osmosis, students used comparative language about solute concentration and the direction of water movement across semipermeable membranes, frequently referring to their own potato data or to plasmolysis observations in elodea.

Quantitatively, the average score on the concept inventory rose markedly, with high growth on items that required transfer to new images. Rubric-based measures showed parallel improvement. Planning and carrying out investigations improved when students redesigned the osmosis test after the first trial to reduce measurement error, for example by blotting potato strips consistently before weighing. Data representation advanced from isolated measurements to coherent tables and graphs with labeled axes and units. Modeling quality progressed from decorative representations to mechanism-bearing diagrams that annotated how the membrane regulates exchange or how mitochondria relate to energy release. In written arguments, claims became more specific, evidence referenced particular micrograph features such as visible cell walls or chloroplast distribution, and reasoning linked structure to function, for instance connecting a central vacuole to turgor pressure and plant rigidity.

Classroom discourse shifted in productive ways. At the start of the sequence, whole-class talk was dominated by teacher questioning with brief student responses that reiterated vocabulary. By the third lesson, more students posed questions, challenged peers’ interpretations of micrographs, and requested additional observations before accepting a claim. The teacher reported that this shift freed her to act as a facilitator who pressed for warrants and guided attention to relevant features rather than as a lecturer who delivered names and definitions. Audio snippets captured more causal connectives and fewer descriptive adjectives, suggesting a move toward explanatory language. The laboratory component also improved inclusivity. Students with initially low confidence found success in producing accurate scaled

drawings, while multilingual learners leveraged visual evidence to communicate ideas even when vocabulary lagged. The osmosis investigation, because it used familiar foods and clear physical changes, engaged students who had previously disengaged during diagram-heavy lessons.

Design principles emerged that explain why the sequence worked. The deliberate alignment of representations—physical models, hand drawings, and micrographs—reduced cognitive load by allowing students to map features across media. Sequencing activities so that observation preceded labeling made labels meaningful and reduced rote memorization. Building revision into both models and procedures cultivated an authentic sense of science as iterative, preventing the misconception that a single observation settles a question. The insistence on writing brief captions with every drawing reinforced the habit of connecting evidence to interpretation, a core practice that transfers readily to later topics. The osmosis investigation illustrated how everyday materials can yield robust conceptual leverage when tasks are structured to produce quantifiable differences and communal analysis.

At the same time, the study identified pitfalls and remedies. In early implementations, some groups treated clay models as art projects and invested time in decorative features that did not advance explanation. The remedy was to constrain materials to functional components and to require annotations that tied each feature to a life function. Another difficulty arose with microscopes: students often over-manipulated focus knobs and lost the specimen. A short, standardized routine for slide handling and focusing, practiced with non-biological grid slides before real specimens, reduced equipment mishaps and recovered time. With osmosis, confusion persisted when students used intuitive terms like “strong” or “weak” solution; requiring numerical concentration labels on cups and insisting on percent mass change calculations grounded language in measurable differences. Formative assessment was essential throughout; exit slips that asked students to draw a simple membrane with arrows indicating water movement exposed lingering misconceptions even when whole-class discussions seemed successful.

Comparisons with the previous year’s cohort, while not experimental, were suggestive. Students taught primarily through presentations showed smaller gains on transfer items and tended to answer micrograph interpretation questions with rote labels rather than with references to observable features. They were less likely to connect structure to function without prompts and rarely used data from class investigations to justify

claims. The activity-based cohort, in contrast, often quoted their own measurements and used language that invoked mechanisms, not just names. Teachers also noted fewer behavior issues during lab-centered lessons, attributing the change to purposeful engagement and shared accountability for data quality.

The methodology appears adaptable to diverse contexts, including resource-constrained schools. Where microscopes are scarce, teachers can rotate a single station while others engage in model revision or osmosis analysis, keeping the class synchronized conceptually. In very low-resource settings, printed micrographs and virtual microscope simulations can stand in while preserving the same reasoning demands. Safety and hygiene considerations for cheek-cell sampling were manageable when the activity was optional and when plant specimens provided the main evidence. Importantly, the approach aligns with cross-cutting skills such as data literacy and argumentation that serve students beyond the cell unit. By making evidence central and treating models as tools for thinking rather than decorations, the sequence develops durable habits that will benefit subsequent units on tissues, organs, and homeostasis.

A coherent sequence of activity-based tasks can transform the 7th-grade cell unit from a memorization challenge into a conceptually rich investigation. When students observe real specimens, build and revise models to solve functional problems, and reason quantitatively about water movement, they assemble a mechanistic understanding of cells that travels across representations and contexts. The approach presented here demonstrates that such learning is feasible within ordinary schedules, inexpensive materials, and typical classroom constraints. Gains in conceptual understanding, practices, and discourse quality suggest that the methodology advances both knowledge and scientific habits of mind. Teachers who adopt the sequence should prioritize representational alignment, insist on brief evidence-linked writing with every observation and model, and use formative assessment to steer inquiry without over-scaffolding. Future work should explore longer-term retention, the effects of adding simple digital tools such as image-capture and annotation on tablets, and the integration of genetics investigations that extend the model-based reasoning cultivated in the cell unit.

REFERENCES:

- Bybee R.W. The BSCS 5E Instructional Model: Origins and Effectiveness. — Colorado Springs: BSCS, 2014. — 36 p.
- Bransford J.D., Brown A.L., Cocking R.R. (eds.). How People Learn: Brain, Mind, Experience, and School. Expanded ed. — Washington, DC: National Academy Press, 2000. — 374 p.
- National Research Council. A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. — Washington, DC: National Academies Press, 2012. — 400 p.
- Hattie J. Visible Learning: A Synthesis of Over 800 Meta-Analyses Relating to Achievement. — London: Routledge, 2009. — 378 p.
- Black P., Wiliam D. Inside the Black Box: Raising Standards Through Classroom Assessment. — London: GL Assessment, 1998. — 13 p.
- Millar R. Practical work in school science: Why is it important? // *School Science Review*. — 2010. — Vol. 91, № 335. — P. 59–64.
- Windschitl M., Thompson J., Braaten M. Ambitious Science Teaching. — Cambridge, MA: Harvard Education Press, 2018. — 312 p.
- Gilbert J.K. (ed.). Visualization in Science Education. — Dordrecht: Springer, 2005. — 325 p.
- Osborne J., Patterson A. Scientific argument and explanation: A necessary distinction? // *Science Education*. — 2011. — Vol. 95, № 4. — P. 627–638.
- Tytler R. A re-imagining of science education: Engaging students in science for Australia's future. — Melbourne: ACER Press, 2007. — 220 p.
- NRC. Inquiry and the National Science Education Standards: A Guide for Teaching and Learning. — Washington, DC: National Academies Press, 2000. — 224 p.
- Novak J.D. Learning, Creating, and Using Knowledge: Concept Maps as Facilitative Tools in Schools and Corporations. 2nd ed. — New York: Routledge, 2010. — 360 p.
- Clement J. Model-based learning as a key research area for science education // *International Journal of Science Education*. — 2000. — Vol. 22, № 9. — P. 1041–1053.
- Harrison A.G., Treagust D.F. A typology of school science models // *International Journal of Science Education*. — 2000. — Vol. 22, № 9. — P. 1011–1026.
- Abrahams I., Reiss M.J. Practical work: Its effectiveness in primary and secondary schools // *Journal of Biological Education*. — 2012. — Vol. 46, № 4. — P. 313–318. — 2010. — Vol. 26, № 10. — P. 891–908.
- Frailon J., Ainley J., Schulz W., Duckworth D., Friedman T. Preparing for Life in a Digital World: The IEA International Computer and Information Literacy Study 2018 International Report. — Cham: Springer, 2020. — 250 p.

International Journal of Pedagogics (ISSN: 2771-2281)

Eshet-Alkalai Y. Digital literacy: A conceptual framework for survival skills in the digital era // Journal of Educational Multimedia and Hypermedia. — 2004. — Vol. 13, № 1. — P. 93–106.

Jisc. Building digital capability: The six elements of digital capability. — Bristol: Jisc, 2015. — 36 p.

Educational Testing Service. Digital Transformation: A Framework for ICT Literacy. — Princeton, NJ: ETS, 2002. — 40 p.

Hair J.F., Black W.C., Babin B.J., Anderson R.E. Multivariate Data Analysis. 8th ed. — Andover: Cengage Learning, 2019. — 834 p.

Tabachnick B.G., Fidell L.S. Using Multivariate Statistics. 6th ed. — Boston: Pearson, 2013. — 983 p.

Nunnally J.C., Bernstein I.H. Psychometric Theory. 3rd ed. — New York: McGraw-Hill, 1994. — 752 p.

Redecker C. European Framework for the Digital Competence of Educators: DigCompEdu. — Luxembourg: Publications Office of the European Union, 2017. — 96 p.