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Action Research on Student Engagement Trends in Blended Learning Classrooms at the Secondary Stage

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Abstract: ***This paper examines reflective action research as a practical and evidence-informed approach for enhancing cognitive engagement in secondary science classrooms. It argues that cognitive engagement is strengthened when teachers use reflection to redesign questioning, experimentation, concept explanation, formative assessment, collaborative inquiry, and blended scientific learning. Drawing on reflective practice, action research, pedagogical content knowledge, technological pedagogical content knowledge, teacher professional development, differentiated instruction, inclusive education, student well-being, and Indian educational policy frameworks, the paper proposes a classroom-based model through which science teachers can identify engagement barriers, implement interventions, and refine pedagogy through systematic evidence. The discussion is situated within the National Education Policy 2020, National Curriculum Framework 2005, NCFTE 2009, NPST 2023, MANODARPAN, NCERT well-being resources, and Indian Knowledge System-based contextual science learning. The paper concludes that reflective action research can transform secondary science classrooms from information-transmission spaces into inquiry-oriented, reflective, inclusive, and cognitively demanding learning environments.***

Keywords: cognitive engagement, reflective action research, secondary science education, inquiry learning, science pedagogy, blended learning, student engagement, reflective teaching

1. Introduction

Science education at the secondary level occupies a foundational place in school learning because it contributes to conceptual understanding, logical reasoning, observation, experimentation, evidence-based thinking, and informed citizenship. At this stage, students are expected to move beyond factual recall and begin to understand how scientific knowledge is constructed, tested, debated, and applied. However, in many classrooms, science continues to be taught in ways that privilege content coverage, memorization of textbook definitions, mechanical numerical problem-solving, and examination-oriented reproduction. Students may attend class, copy notes, complete assignments, and even perform reasonably in tests while remaining only minimally engaged at the level of thought. Such patterns point to a serious pedagogical concern: the difference between participation and cognitive engagement.

The National Education Policy 2020 places strong emphasis on experiential learning, critical thinking, scientific temper, inquiry, flexibility, and the reduction of rote learning (Ministry of Education, Government of India, 2020). The National Curriculum Framework 2005 also argues that science education should help children understand and relate to the natural and social environment through observation, exploration, and reasoning rather than memorization (National Council of Educational Research and Training, 2005). These policy directions clearly support a science pedagogy that strengthens cognitive engagement. Yet such engagement cannot be created simply by changing syllabus language or adding digital tools. It requires teachers who can observe classroom realities, identify learning barriers, experiment with pedagogical strategies, and improve practice systematically.

Reflective action research offers an effective approach for this purpose. Schön (1983) conceptualizes the reflective practitioner as one who thinks in action and on action while responding to complexity. Singh (2014a) presents action research as a practical classroom-based process for identifying problems, planning interventions, implementing changes, collecting evidence, and refining teaching. In science education, reflective action research can help teachers investigate questions such as why students remain passive during experiments, why they rely on memorized answers, why they avoid asking questions, or why they fail to connect concepts with observation. This process enables science pedagogy to become evidence-informed and learner-responsive.

The purpose of this paper is to examine how reflective action research can enhance cognitive engagement in secondary science classrooms. It argues that cognitive engagement improves when science teachers design instruction around inquiry, conceptual questioning, experimentation, reflection, collaboration, formative feedback, and contextual understanding. It further argues that such work should be supported by teacher reflection, professional development, inclusion, differentiated instruction, student well-being, and where appropriate, culturally rooted science contexts drawn from Indian Knowledge System.

1) Cognitive Engagement in Secondary Science Learning

Cognitive engagement is a deeper form of academic involvement than simple behavioural participation. A behaviourally engaged student may attend class, complete homework, and follow instructions, yet may still engage with science at a surface level. Cognitive engagement, by contrast, requires intellectual investment. It includes curiosity, persistence in understanding difficult concepts, willingness to revise misconceptions, use of reasoning, and active search for meaning.

Several barriers weaken cognitive engagement in science learning. One is the dominance of transmission-based teaching in which teachers explain, students record, and assessment rewards recall. Another is the pressure of examinations, which may encourage shortcut learning. A third is the fragmentation of theory and practice, where laboratory activities become ritualized rather than conceptually meaningful. A fourth barrier is learner fear of science as a difficult subject, which may reduce questioning and experimentation. A fifth barrier is the limited use of student voice in understanding how learners experience science concepts. These challenges suggest that improving science learning requires closer attention to classroom processes rather than only curriculum content.

Shulman's (1987) concept of pedagogical content knowledge is highly relevant here. Science teachers need more than subject knowledge; they must know how to represent abstract concepts, anticipate misconceptions, use examples, and design tasks that make ideas understandable. Mishra and Koehler's (2006) technological pedagogical content knowledge framework further extends this insight by showing that in modern classrooms, technology must be meaningfully integrated with science content and pedagogy. Simulations, digital labs, animations, and online formative tools can enhance cognitive engagement only when teachers use them purposefully.

2) Reflective Action Research in Science Classrooms

Reflective action research provides a structured method through which science teachers can address problems of cognitive engagement in their own classrooms. Singh (2014a) explains that action research helps educators address practical problems through a cycle of identification, planning, action, observation, reflection, and revision. In science education, this cycle can be used to investigate conceptual misunderstanding, passive participation in laboratory work, low questioning, weak problem-solving, or superficial use of digital tools.

The first stage is identifying the problem. A science teacher may observe, for example, that students can repeat definitions but cannot explain concepts in their own words; that practical work is completed mechanically; that learners hesitate to ask questions; that only a few students participate in scientific discussion; or that online science resources are viewed passively. The problem should be stated clearly and specifically. A researchable question may be framed as follows: How can structured questioning improve conceptual engagement in chemistry? How can reflective lab sheets improve scientific reasoning in biology? How can student-designed experiments enhance engagement in physics? Such framing moves the teacher from a vague sense of dissatisfaction to a focused inquiry.

The second stage is planning an intervention. Here the teacher selects a practical pedagogical strategy. The intervention may involve guided inquiry tasks, concept maps, prediction-observation-explanation sequences, peer explanation, digital simulations linked with questioning, reflective lab journals, formative quizzes with discussion, or local-context science problems. The intervention should be modest enough to implement but meaningful enough to affect student thinking.

The third stage is action. The teacher implements the strategy in the classroom. Reflection-in-action is especially important here. If students remain confused, silent, or overdependent, the teacher may need to modify prompts, provide scaffolds, or reorganize groups. Science classrooms often involve unpredictability because experiments, student responses, and conceptual misunderstandings develop dynamically. Schön's (1983) notion of reflection-in-action is therefore central to science teaching.

The fourth stage is observation and evidence collection. Evidence may include student responses, discussion quality, reflective writing, lab reports, concept test scores, classroom observation notes, digital participation records, and student feedback. The aim is to determine whether the intervention improved cognitive engagement rather than merely completing the planned activity.

The fifth stage is reflection and revision. The teacher analyses what changed, which learners benefited, what barriers remained, and what needs further adaptation. This process can be repeated across cycles, thereby building a classroom-based culture of scientific pedagogy grounded in evidence.

3) Science Teaching Beyond Transmission

Traditional science teaching often assumes that explanation leads automatically to understanding. However, students frequently memorize scientific statements without integrating them conceptually. For example, a student may recite Newton's laws or the process of photosynthesis without being able to apply these ideas to unfamiliar situations. Reflective action research helps teachers examine where such gaps emerge.

One important shift is from content delivery to conceptual dialogue. Science teachers can ask students to predict outcomes before an experiment, explain results afterward, compare alternative explanations, identify errors in reasoning, or relate concepts to everyday observations. Such strategies require students to engage mentally rather than only listen. Cognitive engagement deepens when students are expected to justify ideas and test them against evidence.

Another shift is from confirmatory laboratory work to inquiry-oriented experimentation. In many classrooms, practical work is treated as the reproduction of a known result. Students follow instructions mechanically and record expected observations. Reflective science teachers can redesign practicals so that students make predictions, discuss variables, interpret unexpected results, and reflect on what evidence means. This transformation is particularly important for cognitive engagement because experimentation should cultivate reasoning, not ritual.

A third shift is from answer-seeking to misconception work. Science learning is filled with misconceptions related to

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force, motion, heat, electricity, cells, heredity, ecosystems, and chemical reactions. Teachers who reflect on student thinking can identify these misconceptions and design interventions that surface and challenge them. Such work requires strong pedagogical content knowledge (Shulman, 1987).

A fourth shift is from isolated teaching to integrated digital and face-to-face learning. Digital pedagogy in science can be powerful when simulations, videos, interactive models, or online quizzes are used not as standalone materials but as part of guided conceptual inquiry. Hodges et al. (2020) remind us that the educational value of digital instruction depends on careful design. Science teachers must therefore reflect on whether digital materials are producing passive viewing or active thinking.

4) Reflective Strategies for Enhancing Cognitive Engagement

Several reflective strategies can be used in secondary science classrooms to strengthen cognitive engagement. One is structured questioning. Instead of asking mainly recall questions, teachers can use predictive, comparative, explanatory, and reasoning-based questions. For example, before a demonstration, students may be asked what they expect to happen and why. Afterward, they may compare their prediction with observation and explain the difference. Such sequences encourage active scientific thinking.

A second strategy is concept representation through multiple modes. Science concepts are often abstract, and students vary in how they understand them. Teachers may use diagrams, models, experiments, analogies, digital animations, tables, graphs, and verbal explanation together. Mishra and Koehler’s (2006) framework is relevant here because technology can support conceptual understanding when pedagogically integrated.

A third strategy is reflective laboratory work. Students can maintain science reflection sheets in which they record not only observations but also predictions, interpretations, sources of error, and conceptual conclusions. This moves practical work from recording to reasoning.

A fourth strategy is peer explanation. Students often understand science more deeply when they explain a concept to a classmate or compare answers in groups. However, peer work must be structured. Clear roles such as predictor, recorder, explainer, checker, or questioner can improve scientific dialogue.

A fifth strategy is formative conceptual assessment. Short diagnostic questions, exit slips, online quizzes, and oral conceptual probes can help teachers see how students are thinking. Guskey (2002) argues that teacher change is strengthened when teachers use evidence of student learning. Formative assessment provides that evidence and helps teachers refine science teaching.

A sixth strategy is contextual science learning. Connecting science with local environment, everyday life, environmental issues, health practices, or Indian scientific traditions can increase relevance and engagement. NCF 2005 strongly supports linking knowledge with life outside school (National Council of Educational Research and Training, 2005). When science concepts are taught through familiar and meaningful contexts, students are more likely to think deeply about them.

5) Blended and Digital Possibilities in Science Classrooms

However, digital tools do not automatically produce better thinking. A long science video watched passively may produce less engagement than a short teacher-led discussion. Therefore, digital science pedagogy must be designed carefully. A simulation should include guiding questions. An online quiz should be followed by analysis of misconceptions. A recorded explanation should connect with a later task. Without such design, blended science teaching may merely extend passive learning across more platforms (Hodges et al., 2020).

Mishra and Koehler’s (2006) TPACK framework is especially useful in science because digital tools can visualize phenomena that are otherwise difficult to observe directly. Molecular processes, astronomical movements, electric circuits, or biological systems can be explored through technology. Yet technology should be selected because it supports conceptual understanding, not because it appears modern. Digital science pedagogy must also remain inclusive. Some students may benefit greatly from repeated access to recorded explanation or interactive visuals, while others may face device limitations or need more teacher guidance. Reflective teachers examine who benefits, who is left behind, and how digital design can be improved for all learners.

6) Inclusion, Differentiation, and Science Engagement

Singh (2014e, 2014f) argues that inclusive education requires a transformation of classroom practices, not merely shared physical space. In science education, this means designing tasks through which all learners can observe, think, ask, and explain. Differentiated instruction is one important route. Singh (2014c, 2014d) emphasizes that teaching should respond to learner diversity in readiness, pace, and style. In science, this may involve providing multiple entry points to a concept, using simpler scaffolds for some learners, giving challenge extensions to others, and offering multiple response formats such as oral explanation, drawing, digital concept map, or short written reasoning. Language is also important. Some students fail to engage cognitively not because they cannot think scientifically, but because they cannot express that thinking in the formal register expected in class. Reflective teachers therefore use accessible explanation, encourage provisional answers, and accept conceptual attempts that can be refined through dialogue. Peer grouping must also be examined. Group experiments sometimes hide exclusion, with one or two students handling the task while others remain passive. Action research can help teachers identify such patterns and redesign group structures. Rotating roles, individual reflection sheets, and peer accountability can improve broader participation.

7) Well-Being, Confidence, and Scientific Thinking

Cognitive engagement in science is closely linked with emotional conditions. Students are less likely to question, hypothesize, or interpret evidence when they fear failure or humiliation. Science anxiety can emerge from repeated experiences of difficulty, comparison, or public correction. Therefore, teachers must create science classrooms where uncertainty and error are treated as part of learning. The Ministry of Education's MANODARPAN initiative and NCERT's work on mental health and well-being emphasize supportive educational environments and teacher sensitivity (Ministry of Education, Government of India, n.d.; National Council of Educational Research and Training, 2022). These concerns are relevant to science classrooms because learners often disengage cognitively when they feel overwhelmed or incapable. Reflective teachers can reduce such barriers by using low-stakes questioning, supportive feedback, incremental challenge, and collaborative exploration. Science learning can also be linked with self-regulation and reflective awareness. Students may be asked to think about how they approached a difficult problem, what misconception they held, what evidence changed their thinking, and what helped them understand. Such metacognitive reflection supports deeper engagement and is consistent with the broader reflective orientation of contemporary pedagogy.

8) Indian Knowledge System and Contextual Science Engagement

Indian Knowledge System can enrich secondary science learning when used as a contextual and inquiry-oriented resource. NEP 2020 encourages rootedness in India along with scientific temper and critical thinking (Ministry of Education, Government of India, 2020). The Ministry of Education's IKS initiative also supports educational engagement with Indian scientific, ecological, and intellectual traditions (Ministry of Education, Government of India, 2023). In science classrooms, this may include local ecological knowledge, historical Indian contributions to astronomy or mathematics, traditional water management, environmental practices, or health-related knowledge examined in appropriate scientific contexts. Singh's work on the Vedas and Upanishads includes discussions of cosmology, mindful inquiry, and the relationship between ancient wisdom and modern questions (Singh, 2024a, 2024b, 2024e). When used carefully, such themes can stimulate scientific curiosity and philosophical reflection. For example, students may explore how different civilizations asked cosmological questions, how observation and interpretation interact, or how ecological balance appears across knowledge traditions. This kind of contextual science learning can make concepts more meaningful and intellectually rich.

9) Teacher Professional Development for Reflective Science Pedagogy

Improving cognitive engagement in science requires teacher development that is pedagogically deep. Teachers need support in conceptual teaching, questioning strategies, inquiry methods, formative assessment, inclusive science pedagogy, and digital integration. Technical workshops alone are insufficient. Darling-Hammond (2006) argues that teachers need preparation for complex and learner-responsive practice. Desimone (2009) emphasizes active learning, coherence, and content focus in professional development. Avalos (2011) highlights the importance of context and collaboration in teacher learning. Guskey (2002) shows that evidence of student improvement strengthens teacher change. These principles suggest that science teacher development should include reflective lesson study, action research, peer observation, and collaborative analysis of student thinking. The National Curriculum Framework for Teacher Education 2009 and NPST 2023 further support reflective teacher professionalism (National Council for Teacher Education, 2009, 2023). Science teachers should be encouraged to document classroom problems, test interventions, analyse evidence, and share insights with colleagues. Such school-based inquiry can gradually transform science pedagogy.

Singh (2014b) emphasizes the need to build a strong pedagogical foundation among teachers, which is highly relevant to science teaching. Conceptual teaching, inquiry support, and engagement design depend on such a foundation. When strengthened through reflective action research, science teachers become more capable of facilitating genuine thinking.

10) A Reflective Action Research Model for Science Engagement

A practical model for enhancing cognitive engagement in secondary science classrooms may include six stages: diagnose, design, inquire, document, interpret, and refine. In the diagnose stage, the teacher identifies a specific cognitive engagement issue, such as rote responses, passive laboratory work, weak conceptual explanation, or low questioning. In the design stage, the teacher plans a targeted intervention. This may include structured questioning, reflective practical work, peer explanation, blended simulations, concept maps, or local-context science inquiry. In the inquire stage, the intervention is implemented while the teacher observes student responses and adjusts support as needed. In the document stage, evidence is collected through student work, observation notes, participation patterns, concept tests, digital responses, and feedback. In the interpret stage, the teacher analyses the evidence to determine whether cognitive engagement improved and for whom. In the refine stage, the teacher revises the strategy and begins another cycle. This model aligns with Singh's (2014a) view of action research and Schön's (1983) reflective practice.

2. Conclusion

Cognitive engagement is central to meaningful science education at the secondary level. Students do not become scientifically literate merely by memorizing definitions or repeating procedures. They need opportunities to think, question, explain, test, interpret, and reflect. Reflective action research offers a powerful way for science teachers to create such opportunities because it links classroom problems with evidence-based pedagogical improvement.

This paper has argued that reflective action research can help science teachers identify barriers to cognitive engagement, redesign pedagogy, integrate digital and practical work meaningfully, support diverse learners, and refine teaching through ongoing evidence. It has also shown that science engagement is connected with teacher knowledge, inclusion, well-being, student voice, and culturally grounded contexts. The discussion aligns with NEP 2020, NCF 2005, NCFTE 2009, NPST 2023, MANODARPAN, and the wider literature on teacher professional development.

The future of secondary science education depends on classrooms where students are not merely present but intellectually alive. Reflective action research provides a practical and professional pathway toward such classrooms. Through it, science teaching can become more inquiry-driven, conceptually demanding, emotionally supportive, inclusive, and contextually meaningful.

References

[1] Avalos, B. (2011). Teacher professional development in *Teaching and Teacher Education* over ten years. *Teaching and Teacher Education, 27*(1), 10–20. https://doi.org/10.1016/j.tate.2010.08.007

[2] Darling-Hammond, L. (2006). Constructing 21st-century teacher education. *Journal of Teacher Education, 57*(3), 300–314. https://doi.org/10.1177/0022487105285962

[3] Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher, 38*(3), 181–199. https://doi.org/10.3102/0013189X08331140

[4] Fullan, M. (2007). *The new meaning of educational change* (4th ed.). Teachers College Press.

[5] Guskey, T. R. (2002). Professional development and teacher change. *Teachers and Teaching, 8*(3), 381–391. https://doi.org/10.1080/135406002100000512

[6] Hodges, C., Moore, S., Lockee, B., Trust, T., & Bond, A. (2020, March 27). The difference between emergency remote teaching and online learning. *EDUCAUSE Review*.

[7] Ministry of Education, Government of India. (2020). *National education policy 2020*. Government of India.

[8] Ministry of Education, Government of India. (2023). *Indian knowledge systems*. Government of India.

[9] Ministry of Education, Government of India. (n.d.). *MANODARPAN: Psychosocial support for mental health & well-being of students*. Government of India.

[10] Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017–1054. https://doi.org/10.1111/j.1467-9620.2006.00684.x

[11] National Council of Educational Research and Training. (2005). *National curriculum framework 2005*. NCERT.

[12] National Council of Educational Research and Training. (2022). *Mental health and well-being of school students: A survey*. NCERT.

[13] National Council of Educational Research and Training. (n.d.). *Health and well-being modules*. NCERT.

[14] National Council of Educational Research and Training. (n.d.). *Training resource material on emotional well-being and mental health*. NCERT.

[15] National Council for Teacher Education. (2009). *National curriculum framework for teacher education 2009: Towards preparing professional and humane teacher*. NCTE.

[16] National Council for Teacher Education. (2023). *NPST guiding document, 2023*. NCTE.

[17] Schön, D. A. (1983). *The reflective practitioner: How professionals think in action*. Basic Books.

[18] Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1–23. https://doi.org/10.17763/haer.57.1.j463w79r56455411

[19] Singh, H. (2013, September). *Role of education systems in meeting employer's need for skills* [Conference paper]. ICSSR North-Western Regional Conference on Skill Development at Workplace, Chandigarh, India.

[20] Singh, H. (2014a). *Action research for educators* (1st ed.). VL Media Solutions. https://doi.org/10.13140/RG.2.1.1415.8161

[21] Singh, H. (2014c, March). *Differentiating classroom instruction for diverse learners* [Conference paper]. ICSSR National Conference on Redesigning Classroom Environment: Road to Reform, Indo Global College of Education, Mohali, India.

[22] Singh, H. (2014d). Differentiating classroom instruction to cater learners of different styles. *Indian Journal of Applied Research, 3*(12), 58–60.

[23] Singh, H. (2014e, March). *Rethinking and redefining inclusive education* [Conference paper]. ICSSR National Seminar on Marching to Different Drummers: Inclusive Education through Teacher Education, Rayat & Bahara College of Education, Sahauran, Punjab, India. https://doi.org/10.13140/RG.2.1.1500.0407

[24] Singh, H. (2014f). *Inclusive education in India: A metamorphosis* (1st ed.). VL Media Solutions. https://doi.org/10.13140/RG.2.1.2327.6881

[25] Singh, H. (2014g, November). *Value education in schools: Concepts and concerns* [Conference paper]. National Seminar on Declining Values—A Challenge for Education, Guru Nanak College of Education, Hoshiarpur, Punjab, India. https://doi.org/10.13140/RG.2.1.1024.9047

[26] Singh, H. (2015a). Envisioning the examination reforms in higher education system. *International Journal of Research in Economics and Social Sciences, 5*(6), 1–7.

[27] Singh, H. (2024a). *Echoes of eternity: The Vedas and modern cosmology*. Educators Plus. https://doi.org/10.5281/zenodo.19027392

[28] Singh, H. (2024b). *The essential Vedas: Wisdom for the modern world*. Educators Plus. https://doi.org/10.5281/zenodo.19028972

[29] Singh, H. (2024c). *Leadership lessons from the Vedas*. Educators Plus. https://doi.org/10.5281/zenodo.19028084

[30] Singh, H. (2024d). *Living the Upanishads: Ancient wisdom for today's challenges*. Educators Plus. https://doi.org/10.5281/zenodo.19027140

[31] Singh, H. (2024e). *The science behind the Upanishads*. Educators Plus. https://doi.org/10.5281/zenodo.19027625

[32] Singh, H. (2024f). *Upanishads for a new age*. Educators Plus. https://doi.org/10.5281/zenodo.19028646

[33] Singh, H. (2024g). *Vedic wisdom for mindful living*. Educators Plus. https://doi.org/10.5281/zenodo.19028189

[34] Singh, H., & Gera, M. (2015a). Developing generic skills in higher education. *Indian Journal of Applied Research, 5*(6), 824–826. https://doi.org/10.15373/2249555X/June2015/50

[35] Singh, H., & Gera, M. (2015b). Generic skills for sustainable development. *Paripex - Indian Journal of Research, 4*(6), 290–292.

[36] Singh, H., & Gera, M. (2015c). Pedagogical rejuvenation and quality deliverance for effective teaching. *Global Journal for Research Analysis, 4*(6), 115–117.

[37] Singh, H., & Gera, M. (2015d). Strategies for development of life skills and global competencies. *International Journal of Scientific Research, 4*(6), 760–763.