

**Scientific Inquiry in
secondary science: an
international collaboration**

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How the project has progressed

This project came about through cooperation which developed at ASE conferences in Sheffield, Nottingham and Northampton.

Both Ade and Glenys were members of the ASE international Group for a number of years.



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Visits to schools



Glenys and Ade visited Sofia Bulgaria for a week in June 2024. Nasko arranged one day visits to 3 separate schools. These included private and state schools. He had further agreed with a range of teachers, university tutors, and university staff to allow lessons to be observed and to have in-depth meetings.

What we observed

Small laboratories, students are sitting close together. Most labs do not have gas and some teachers use spirit burners for heating. The concept of whole class practical is very difficult to achieve. Even demonstrations from the teachers are hard for a number of the students to see clearly.



How the research was carried out

- 11 teachers were interviewed from various schools
- 12 teachers completed questionnaires
- 79 students completed questionnaires

Focus of students' questionnaires:

How did they learned science before and during the COVID-19 pandemic; how science experiments were carried out before, during and after COVID-19; experience of using video conference visit to science establishments; and using online science experiments

Teachers' questionnaires: experience of teaching; teaching methods before and during the pandemic; experience of online science experiment; science experiments taught before the pandemic



Image by Chatbot GPT

Research Aim

The background of the slide features a blurred image of laboratory glassware, including a beaker with a pipette, a graduated cylinder, and other vessels, set on a white surface. The overall aesthetic is clean and scientific.

- Investigate pedagogy changes in Bulgaria
- Examine impact on teaching and learning
- Understand challenges and opportunities

Research Questions

A background image of a laboratory setting. In the foreground, a glass beaker contains a clear liquid, with a pipette resting inside it. To the right, another glass beaker is partially visible. In the background, a large glass flask is partially visible. The scene is brightly lit, creating soft shadows on the white surface below.

- How have pedagogical changes shaped teaching?
- What is the current state of inquiry learning?
- How aligned is practice with national aims?

Challenges in Bulgaria



- Curriculum improvement required
- Teacher PD inconsistent
- Resource scarcity limits practical science
- PISA 2019: Lower performance in reading & science

Results: themes generated (Phase 1 findings)

- Digitalisation of education and online learning
- Teacher pedagogical knowledge and promoting student-led learning. **(Dominant of the outcome)**
- Tailored professional development support for teachers
- Lack of resources for practical work impacting on inquiry learning

These results were from teacher interviews

Phase 2 Progress

Phase 2 started with impact of intervention

- Interventions implemented:
 - Micro-scale practical and progress on this
 - Restructure of the chemistry curriculum

Nasko to discuss the above and progress so far.

- Data analysis ongoing and some outcomes: for this conference, we will present outcomes from the students' questionnaires and observation from lesson.

Intervention

Small laboratories, students are sitting close together. The concept of whole class practical is very difficult to achieve. Even demonstrations from the teachers are hard for a number of the students to see clearly.

Nasko and colleagues have been experimenting with the concept of micro-scale practical to try to ensure that students have hands-on experiences .



Bulgaria-specific evidence (2024–25)

- **Secondary + university-linked implementation (Sofia): Nasko Stamenov (National High School of Science & Mathematics, Sofia + Sofia University)**
scienceinschool.org
- **International dissemination in 2024 (ICCE / 12th International Symposium on Microscale Chemistry, July 2024)**
An ICCE 2024 abstract titled “**Outreach and Optimization of the Chemistry Education in Bulgaria using the Microchemistry Approach**” (Stamenov) explicitly links microscale practicals to:
 - a **new Bulgarian school programme** (introduced in the last ~5 years) requiring **more in-depth chemistry and more practical work**
 - constraints like **limited preparation time and reagents**
- An ICCE 2024 abstract titled “**Outreach and Optimization of the Chemistry Education in Bulgaria using the Microchemistry Approach**” (Stamenov) explicitly links microscale practicals to:
 - a **new Bulgarian school programme** (introduced in the last ~5 years) requiring **more in-depth chemistry and more practical work**

Phase 2 outcome

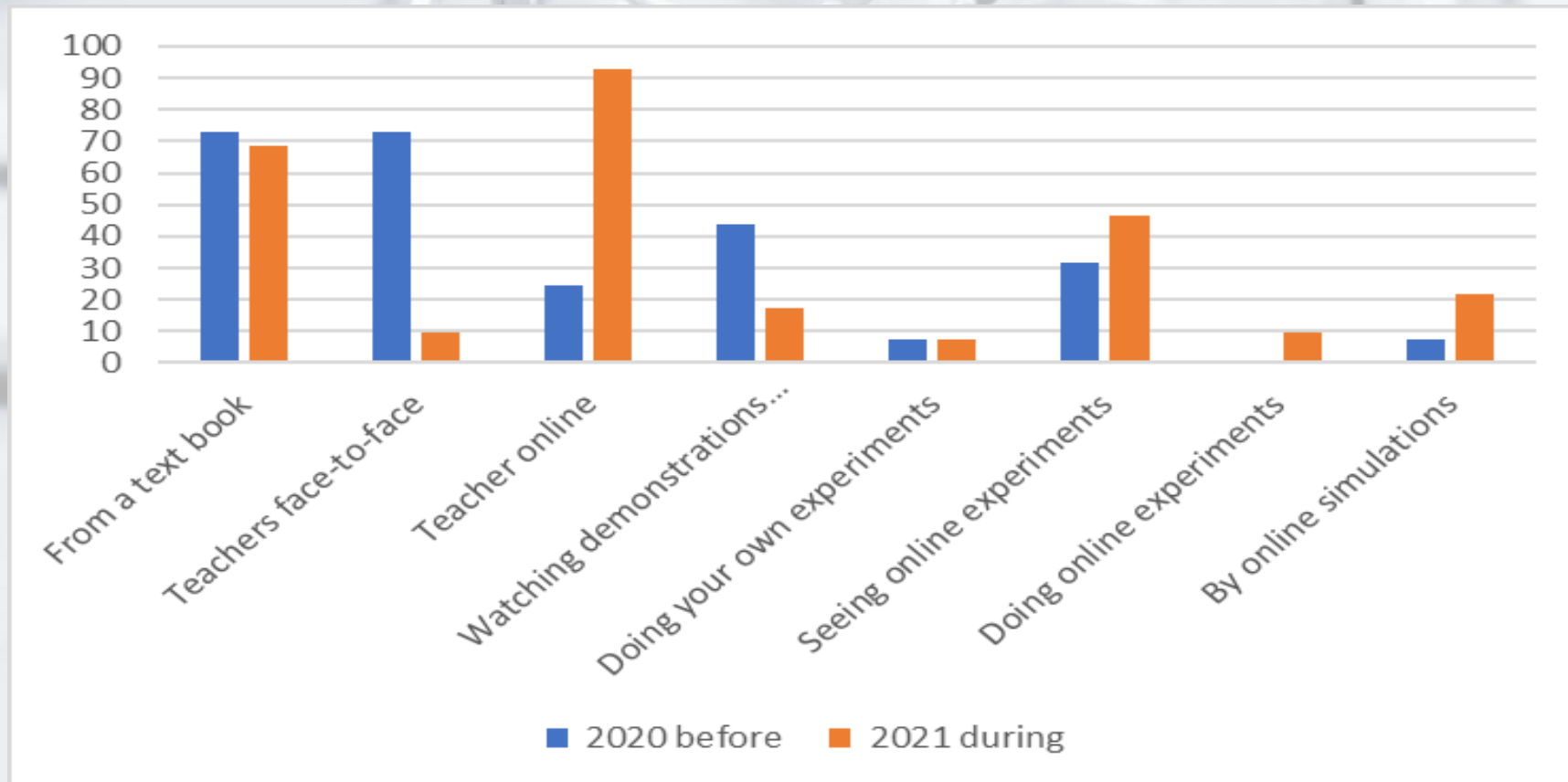
The background of the slide is a blurred photograph of laboratory glassware. In the foreground, a beaker contains a clear liquid, with a pipette tip resting inside it. Behind it, another beaker is visible, and to the right, a graduated cylinder. The scene is set on a white surface, likely a lab bench, with soft lighting creating a clean, scientific atmosphere.

School characteristics:

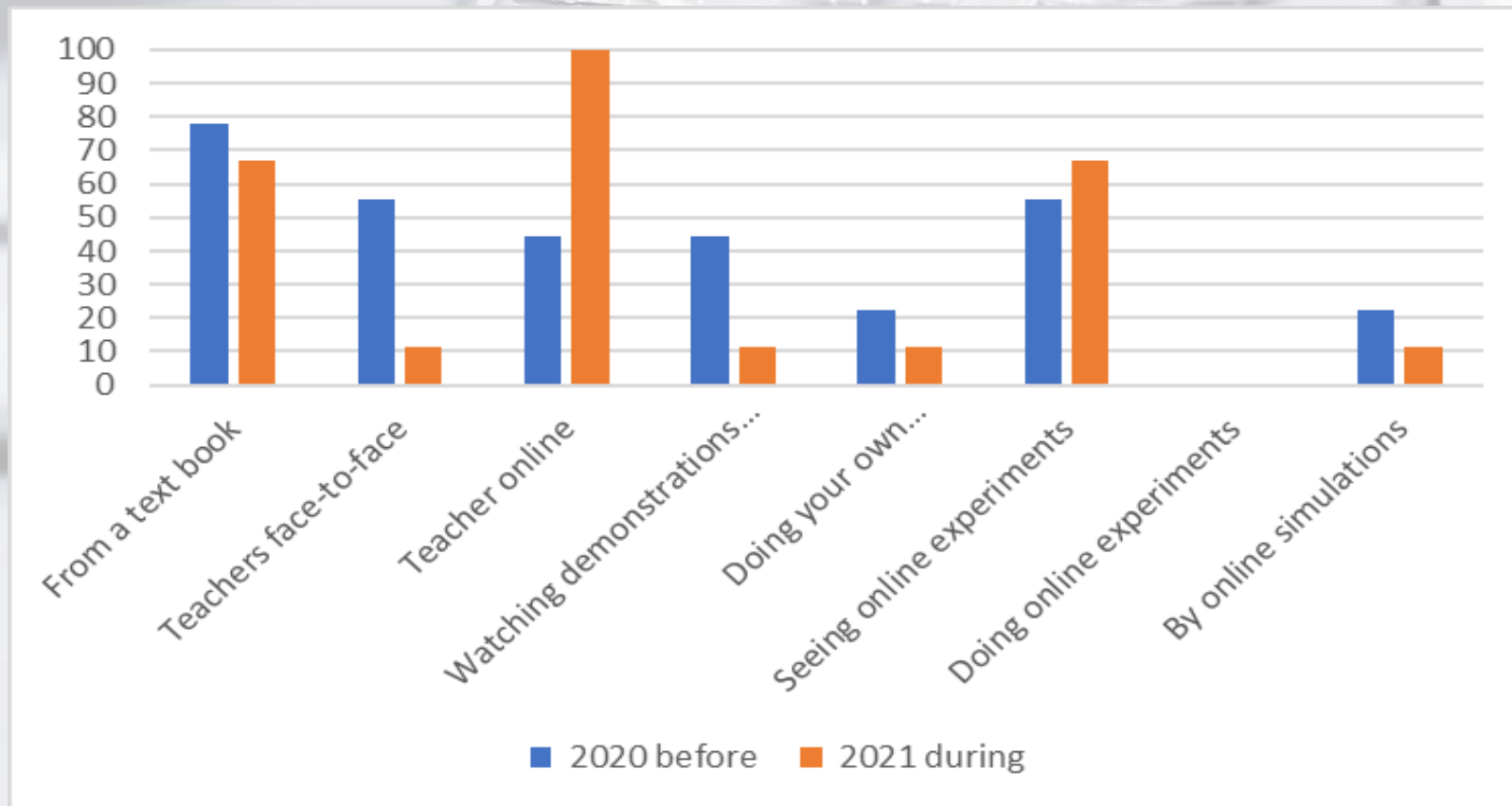
- **School 1** – non-profiled, municipality-funded
- **School 2** – profiled, privately funded
- **School 3** – profiled, government-funded (public)

Different modes of teaching and learning 2020 and 2021

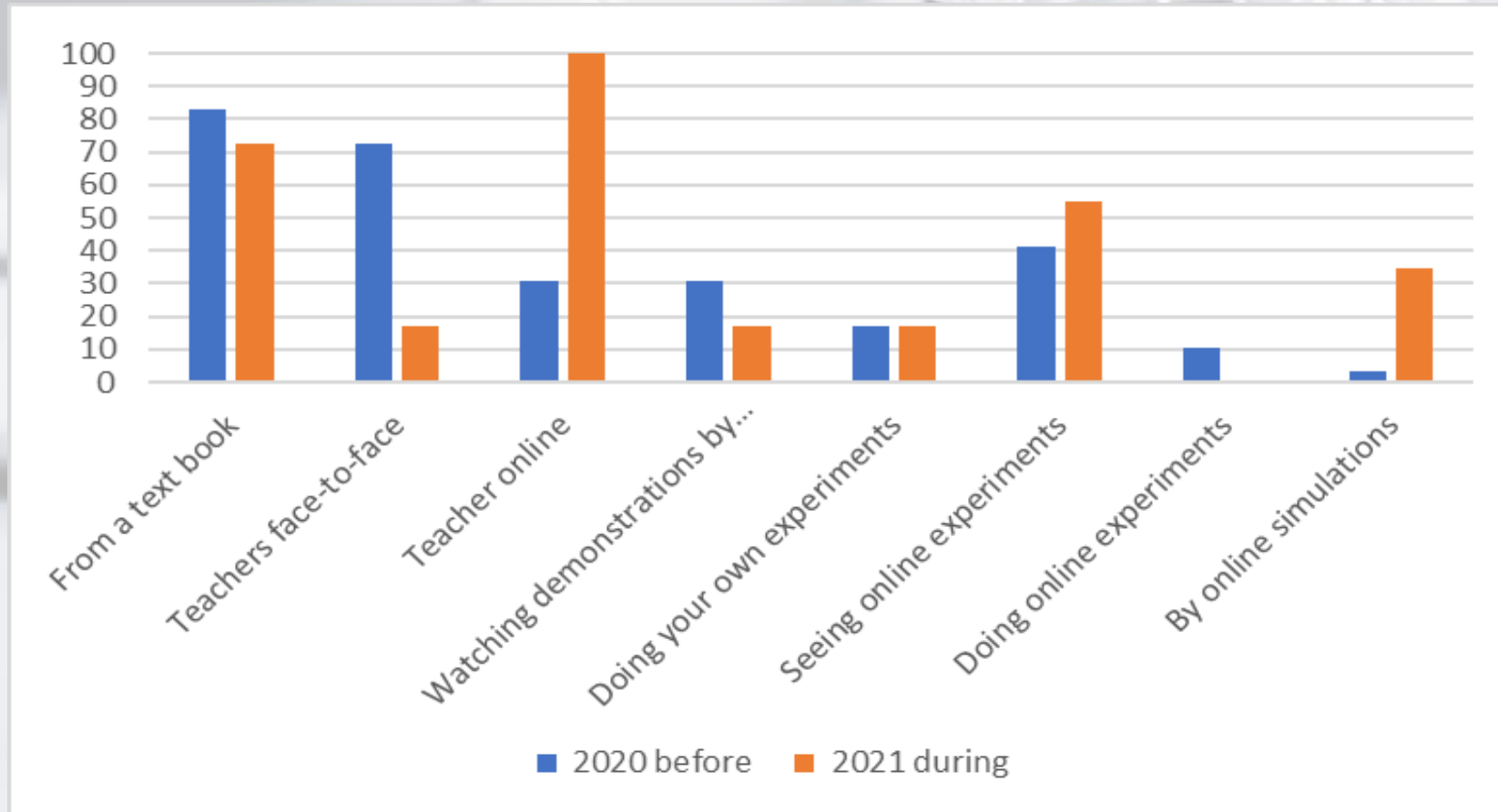
School 1: non-profile high school with municipality budget



School 2: profiled high school with private budget



School 3, profiled high school with government budget (public school)



Data confirms existing tensions

Based on curriculum reviews and teacher accounts:

- Strong emphasis on content coverage
- Limited protected time for: inquiry; experimental design and reflective learning
- Practical work often:
demonstration-based
constrained by resources
Technology introduced as an add-on, not a pedagogical redesign

Outcome from all schools

- No single teaching method shows a strong, consistent correlation with student learning outcomes across schools or time periods.
- Traditional modes (textbook use, face-to-face teaching) correlations weaken or fluctuate during 2021
- Digital and remote modes (online teaching, simulations, online experiments) show small, inconsistent positive correlations
- Hands-on practical work (doing your own experiments) shows loss of strength or instability during pandemic conditions.

Note: emergency remote teaching disrupted the normal relationship between pedagogy and learning

Teachers adapted rapidly, but conditions mattered more than methods

Information from our data

- The rigidity and the conservatism of curriculum delivery prevent innovation in times of need
- Textbooks are the main source of learning.
- During online teaching there are far less demonstrations done by the teacher, possible explanations could be rigidity of curriculum, time and materials restraints.
- The quantity of experiments done by students is small.
- On-line experiments and on-line simulations are strictly case by case for the schools, with some realising on-line learning as an opportunity to do more practical.

Outcome

- The study shows that even well-resourced schools struggled pedagogically during crisis conditions (e.g. the private school example). Tools alone does not enhance learning; pedagogical impact is important as thus:
 - teacher confidence
 - student autonomy
 - assessment design
 - access to equipment
 - emotional and social stress (pandemic effect)

Why this study matters



- Science education depends on:
 - practical work/investigation/inquiry learning
 - interaction
 - modelling and explanation

COVID-19 disrupted all these

Teacher voice matters



From our interviews:

- CPD was uneven
- Training often tool-focused, not pedagogical
- Teachers wanted:
 - practical support
 - examples
 - time to experiment safely

Discussion focus

What strategies are you using to promote inquiry learning in your countries? Discussion point

Our experience from this study shows:

- Strategies to overcome lack of resources to promote inquiry learning- e.g. importance of micro-scale practical
- Collaboration from local universities and schools etc.
- CPD for teachers

Effective science learning requires



- pedagogical coherence: curriculum content, teaching methods/assessments
- teacher confidence
- aligned assessment/assessment reform
- inquiry-based design
- curriculum flexibility
- CPDs for teacher/teacher learning
- hybrid practical work
- simulations as conceptual bridges



Unexpected learning

While girls slightly outperformed boys in science (by two score points) on average across OECD countries in PISA 2018, **in Bulgaria girls outperformed boys in science by 15 score points**

Amongst high-performing students in mathematics or science, one in seven boys in Bulgaria expect to work as an engineer or science professional at the age of 30, while one in nine girls expects to do so (the difference is not statistically significant)



What can you gain from international experience?

Photo by [Al Soot](#) on [Unsplash](#)



- Achieve positive change in your country
- Realise that there is more than 1 way to do something - sometimes better ways
- Understanding that there are many similarities with teachers and students across the world
- Increase in professional knowledge and skills to share ,
- improved motivation,
- Greater awareness of, social history, international literature and world politics

Teachers Resources and opportunities



Key contrasts in microscale use

- **GB UK vs BG Bulgaria**
- **UK:** microscale is a *solution to safety and workload* within a stable system
- **Bulgaria:** microscale is a *solution to curriculum reform + resource constraints*
- Bulgaria is where the UK was **10–15 years ago** in adoption trajectory
- **JP Japan as the benchmark**
- Japan shows what happens when microscale chemistry is:
 - embedded in **teacher education**
 - aligned with **national pedagogy**
 - normalised rather than “alternative”
- Strong model for **system-level change**
- **IN India as the access model**
- Microscale chemistry used to **democratise practical science**
- Particularly relevant for:
 - large student numbers
 - uneven lab infrastructure
- Powerful equity narrative for international policy audiences

Countries Using Microscale Chemistry (Schools & Universities)

us United States

- **One of the global leaders**
- Longstanding tradition since the 1990s (e.g. **Nuffield-inspired and Green Chemistry movements**).
- Widely used in:
 - High schools (AP Chemistry)
 - Undergraduate general chemistry labs
- Strong links to **green chemistry**, waste reduction, and lab safety.
- Supported by ACS (American Chemical Society) publications and textbooks.
- **Status:** Systematic, mainstream

GB United Kingdom



- Supported by **RSC, CLEAPSS, ASE**
- Used mainly in:
 - Secondary schools (GCSE & A-level practicals)
 - Initial teacher education
- Less embedded at university level, but growing in first-year labs and education degrees.
- **Status:** Well-established in schools; selective in universities

ZA South Africa









- Used in:
 - Schools with limited laboratory infrastructure
 - Teacher training programmes
- Strong alignment with **equity and access** agendas.
- **Status:** Targeted, equity-focused

BG Bulgaria



- Emerging but **clearly documented (2024–25)**:
 - Secondary schools
 - University-linked teacher education
- Driven by curriculum reform + resource constraints.
- **Status:** Developing, reform-driven

Common Drivers Across Countries

-  **Safety** (especially in schools)
-  **Cost reduction**
-  **Green chemistry / sustainability**
-  **Lack of full laboratory infrastructure**
-  **Teacher workload and preparation time**
-  **Curriculum mandates for practical work**



Thank you for your ideas and participation!

Any questions or comments?