BIOSHIELD

Novel Biotechnological Solutions in Climate Change Mitigation

REPORT

Educational Technologies and Design Thinking in Agricultural Biotechnology Teaching

Prepared by MELLIS EDUCATIONAL TECHNOLOGIES



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IKY

LICENCE AND ACKNOWLEDGEMENTS

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1. Purpose of this report

This report explains why educational technologies and design thinking are central to the BIOSHIELD higher education curriculum, and it sets out a structured methodology that lecturers can follow to apply both in their own courses. It is written for teaching staff in the partner universities and in any other department that adopts the course.

2. Project background

BIOSHIELD is a 24-month Erasmus+ cooperation partnership (01 October 2024 to 30 September 2026) that responds to three programme priorities:

- Environment and the fight against climate change,
- Innovation and entrepreneurial skills of students,
- Innovative learning and teaching practices.

Its curriculum is proposed to build around ten real problems in five modules, asking biotechnology undergraduates to work on solutions for carbon capture, climate-smart farming, sustainable food systems, waste management, and plant-based remediation.

Two of the six project objectives frame this report.

- **OB3** asks the partnership to enable undergraduates to connect data with practical and transversal skills for biotechnology in the context of climate change and disaster mitigation.
- **OB4** asks it to enrich students' learning experience with educational technologies tailored to the BIOSHIELD course delivery process. BIOSHIELD also commits the project to being a scientific-based example of integrating design thinking and blended learning in course delivery.

The need was confirmed before the project began. In the needs analysis reported in the application form, 50 academics and industry representatives from the partner countries answered as follows.

100%	**97.3%**	**83%**	**97.7%**
say climate change affects agriculture and food safety	expect biotechnological approaches to be effective against climate damage	believe university students can use these approaches effectively	say students need training in order to do so

3. Why educational technologies matter in agricultural biotechnology teaching

3.1 The teaching problem

Agricultural biotechnology is hard to teach with lectures and a weekly practical alone. Much of what students must understand cannot be seen directly: gene editing, microbial colonisation of roots or carbon fixation happen at the molecular scale, while their consequences appear at field and landscape scale over whole growing seasons.

Laboratory and greenhouse time is limited and costly, so it should not be spent on first explanations. The field also moves quickly, and graduates are expected to arrive in industry already able to handle data, work in teams and explain their science. BIOSHIELD identifies exactly this gap: graduates have a strong theoretical background but need more laboratory experience and transversal skills to apply it.

3.2 The BIOSHIELD animated video tutorials

BIOSHIELD Work Package 3 answers this with animated video tutorials that explain innovations and challenges in the biotechnology sector and their importance for mitigating the climate crisis. We foresee ten animations of up to five minutes, two per partner university, with content written by the partner academics, technical production by Mellis Educational Technologies, and dubbing or subtitling so that every video is available in the five project languages. In line with the partner universities' decisions, they may cover carbon capture and utilisation, sustainable and climate-resilient agriculture, bio-based materials and renewable resources, ecosystem restoration, and waste reduction in a circular economy, and they will be published as open educational resources on the project website (www.bioshieldproject.com/index.html) and YouTube channel, which is already active (https://www.youtube.com/channel/UC35EdarQDQukKdzAswEidTA).

Short animations suit this subject because they make invisible mechanisms visible and compress slow processes into minutes. We name four further advantages accordingly:

- Students can watch at a time that suits them,
- Pause and replay difficult sections,
- Engage and participate more,
- Retain more because cognitive overload is reduced.

Most importantly, the videos make flipped learning possible. Bergmann and Sams (2012) and Talbert (2017) notes that flipped learning depends on video, yet most teaching videos are never made public. Open, multilingual videos remove that barrier for any department.

3.3 How each technology answers a teaching challenge

Teaching challenge	Technology used in the curriculum	What it adds
Abstract, invisible processes	Animated video tutorials on mechanisms and applications	A shared mental model before students enter the laboratory
Limited contact and laboratory time	Flipped learning: videos and readings studied before class on the learning platform (Moodle)	Class time is freed for discussion, wet-lab work and projects
Field and landscape scale	QGIS with open satellite and soil data, interactive web maps (Module 3)	Links micro-level biology to real farming conditions
Working with experimental data	Dry-lab analysis and statistical software (SPSS)	Data skills that the industry expects of graduates
Idea generation in teams	Padlet pages and shared digital boards	Every idea is visible, comparable and kept for later stages
Mixed languages and backgrounds	Five language versions, subtitles, self-paced viewing	Inclusive access, including for students who need extra support
Communicating science	Student-made videos, posters and short pitches	Practice in explaining solutions to non-specialists and industry

4. Why design thinking belongs in the BIOSHIELD curriculum

Educational technology improves how knowledge reaches students. Design thinking determines what they then do with it. BIOSHIELD defines it as a problem-solving approach that teams use to understand and redefine problems, challenge assumptions and create innovative solutions to prototype and test, and it requires the curriculum to follow the five stages of empathise, define, ideate, prototype and test. The stated goal is to give students the foresight to apply their knowledge and skills in their future professional settings before they formally begin their careers.

Design thinking is important for this curriculum for five reasons.

- **It starts from real problems.** Climate change presents open, systemic problems with many stakeholders. In the empathise and define stages students interview farmers, take stakeholder roles and frame the question themselves, instead of receiving a ready-made exercise.
- **It makes research idea creation and laboratory work purposeful.** Students enter the laboratory to build and test their own prototype, so techniques are learned as means to an end. The project target is that 90% of student groups develop a prototype.
- **It builds transversal skills.** Teamwork, communication, creativity and data-based decisions are practised in every stage; the project aims for 80% of students to improve these skills.
- **It connects students with industry.** Industry representatives help choose the ideas to prototype, open their laboratories and give feedback, and students present results at the biotechnology fairs. Interested companies may offer early contracts.
- **It supports entrepreneurship.** Testing whether a prototype is useful and marketable prepares students for start-ups; at least 40% of participants are expected to express an intention to start a business.

4.1 The five stages in the curriculum

Stage	What students do	Proposed examples for the curriculum modules
Empathise	Understand the problem and the people or systems it affects	Module 3: teams interview farmers, scientists or land managers about soil microbiomes. Module 2: role-play of food-system stakeholders facing a disruption
Define	Reduce what they learned to one clear, workable problem	Module 1: each group selects one key scientific problem in cultured meat production, such as reducing reliance on fetal bovine serum
Ideate	Generate many ideas, then select and plan the strongest	Module 2: sticky-note sessions on alternative protein sources, followed by a project proposal with objectives, methods and impact
Prototype	Build a first working version in the laboratory or on screen	Module 1: pilot-scale starter culture production on food and agro-waste. Module 3: a pot experiment with microbial inoculants, or an interactive GIS map
Test	Present, collect feedback and refine	Module 3: another team tests the map for clarity and each team gives a two-minute investor-style pitch; final presentation to an invited expert

The two approaches depend on each other. The empathise stage is also the first step of flipped learning, because students meet the industrial problem through the video tutorials before class. The technology supplies the knowledge at the right moment; design thinking gives that knowledge a use.

5. Structured application methodology

The methodology below combines the proposed course delivery design with the weekly teaching and learning process in the curriculum. It assumes one problem per semester, groups of four or five students, and one session of 3 × 45 minutes per week. Modules with long experiments, such as the pot experiment in Module 3, extend the prototype and test stages to 15 weeks.

5.1 The five-stage cycle

Stage	Weeks	Before class (flipped)	In class	Output
Orientation	1	None	Present aims, timeline, assessment and resources; form groups; each group chooses a problem	Groups and chosen problem
Empathise	2	Watch the video tutorial; read the starter literature	Directed discussion, expert input, role-play or stakeholder interviews	Shared description of the problem and who it affects

Stage	Weeks	Before class (flipped)	In class	Output
Define	3–4	Study literature; record a short video or prepare a poster on the challenge	Present and question each group's findings; narrow to one scientific problem	Problem statement or research question
Ideate	5–8	Watch method videos; post ideas on SMS groups	Brainstorm many ideas, select the strongest, draft a proposal with objectives, methods and budget	Approved project proposal
Prototype	9–11	Watch the BIOSHIELD videos to refresh knowledge. Plan experiments; keep observation logs and upload data	Wet- and dry-lab work with a mentor; selection and support from industry representatives	Working prototype or research result
Test	12–13	Analyse results; prepare report and presentation	Present to academics and experts; receive feedback and refine	Final report, presentation and reflection

5.2 Steps for the lecturer

1. **Prepare the digital environment.** Upload the video tutorials, readings and templates to the learning platform, create one Padlet page per group, and check that the videos are available in the teaching language.
2. **Agree on the industry contribution.** Before the semester, meet associated partners to schedule expert input in the empathise stage, laboratory access in the prototype stage and attendance at the final presentations.
3. **Run the cycle as scheduled.** Keep pre-class tasks short and check them at the start of each session, so that class time is used for discussion and practical work.
4. **Mentor the research idea or prototype.** Assign a doctoral or postdoctoral researcher to each group and hold regular progress meetings. Treat a return from test to prototype as a normal part of the process.
5. **Assess process and product.** Combine formative checks (posters, videos, proposal) with the final report and presentation, and use students' video testimonials as self-assessment.
6. **Review and share.** Collect feedback from students and industry, adjust materials for the next cohort, and present the best prototypes at the biotechnology fair.

5.3 Roles

Who	Responsibility
Lecturer	Designs the semester plan, selects the problems, facilitates discussion in class and assesses the work
Mentor (doctoral or postdoctoral researcher)	Follows one or more groups through the ideate and prototype stages and supports laboratory work
Students	Complete the pre-class tasks, work in fixed groups of four or five, document their process and present the result
Industry and associated partners	Bring real problems, help select ideas, open laboratories and give feedback on usefulness and market potential
Educational technology support	Maintains the videos, language versions and platforms, and helps staff use them

5.4 Monitoring the results

BIOSHIELD sets the following thresholds, which can be used directly as course-level indicators.

Indicator	Target	Means of verification
Students who improve their transversal skills	80%	Satisfaction questionnaire
Students who increase their research skills in biotechnology	80%	Satisfaction questionnaire
Student groups that develop a prototype	90%	Prototypes and reports
Students engaged in laboratory work to test prototypes	90%	Laboratory records
Attendance required for certification	70%	Attendance lists, certificates
Industry representatives who rate the training as successful	80%	Interview form

5.5 Conditions for success

- **Keep the videos short and tied to a task.** Each tutorial should be followed by a question, a quiz or a post on the group board, so that viewing is checked and feeds the next session.
- **Do not shorten the early stages.** Groups that hurry through empathise and define tend to prototype the wrong problem. The curriculum gives these stages three weeks for that reason.
- **Expect many ideas before choosing one.** BIOSHIELD asks for many ideas at the ideate stage, including ones that seem out of the box, so that the choice of prototype is a real choice.
- **Plan for inclusion.** Offer subtitles and additional materials to students who need them, and keep regular contact with those at risk of dropping out.
- **Keep the materials current.** All results are open access, and each partner may adapt and build on them so that the content continues to match industry needs.

6. Conclusion

Educational technologies and design thinking do different jobs in the BIOSHIELD curriculum, and each is weaker without the other. The animated videos and digital tools give every student, in their own language and at their own pace, the understanding needed to take part. Design thinking turns that understanding into a tested solution to a real climate problem, developed with industry. Departments that adopt the curriculum are advised to keep the two together: use the videos as the flipped entry point of every cycle, protect class time for practical and team work, and involve industry partners from the first stage to the last.