Handbook of Activity Design

Volume 5: University Students

iGEM Team JLU-CP 2025

Contents

Purpose of This Handbook

The purpose of this third volume is to **extend the structured framework of educational activity design** from primary school to the **university stage (typically ages 18–25)**, a pivotal period when young adults transition from "acquiring knowledge" to "creating knowledge." University students have solid foundational scientific literacy, developed critical thinking skills, and are beginning to **form independent perspectives on social ethics, technological boundaries, and future development**. Thus, the activities compiled in this handbook aim to deepen their understanding of cutting-edge interdisciplinary fields (such as the intersection of synthetic biology and AI) while fostering their ability to engage in in-depth speculation, cross-cultural collaboration, and innovative expression.

Specifically, this handbook serves four interconnected purposes:

1. **Pedagogical Advancement**
   To bridge the gap from theoretical knowledge acquisition to practical application and critical inquiry. Unlike primary school activities that focus on model-building and conceptual understanding, university-level activities emphasize in-depth analysis of complex issues, ethical reflection on **technological development, and interdisciplinary integration of knowledge**.
2. **Knowledge Transfer and Sustainability**
   To document our practical experiences in a **replicable and scalable** format, enabling future teams and educators to build upon, adapt, and refine proven activity models. By positioning this handbook as part of a multi-volume series, we strengthen the **spiral curriculum** for lifelong science learning, ensuring continuity in science education from early childhood to higher education.
3. **Integration of Interdisciplinarity and Innovative Thinking**
   To embed synthetic biology education within **interdisciplinary frameworks** that combine science, technology, ethics, art, and global perspectives. University students are uniquely positioned to benefit from the fusion of these fields—for example, exploring the ethical implications of synthetic biology through debates, or expressing scientific concepts through AI-assisted art—thereby **cultivating innovative thinking that transcends disciplinary boundaries**.
4. **Societal and Professional Relevance**
   To help university students recognize that synthetic biology and its interdisciplinary applications are not confined to laboratories but are closely linked to **real-world challenges (such as food security, environmental protection, and medical innovation) and future career development**. Activities in this volume—whether lectures on AI-synthetic biology integration, experimental camps, or cross-cultural roundtables—highlight the relevance of these fields to social progress and individual professional growth.

In summary, this handbook is both **a record of our team's educational practice and a blueprint for future innovation**. It is designed not only to equip university students with knowledge of synthetic biology and related interdisciplinary fields but also to **cultivate their habits of critical thinking, ethical reflection, cross-cultural collaboration, and innovative expression**.

Guiding Philosophy

The guiding philosophy of this volume reflects the **developmental transition** from primary school to university learning. While primary school students learn best through hands-on modeling and narrative framing, university students (ages 18–25) are ready to **move from conceptual understanding to in-depth speculation, from individual exploration to cross-cultural collaboration, and from knowledge replication to innovative creation**. Our approach therefore emphasizes a balance between **academic rigor, ethical reflection, interdisciplinary integration, and creative expression**.

This philosophy rests on four interrelated principles:

1. From Understanding to Critical Inquiry

At the university level, students no longer simply ask "what is synthetic biology" or "how does AI assist scientific research," but rather "what are the potential risks of synthetic biology" and "how should we balance technological advancement with ethical boundaries." Our activities are thus designed to go beyond surface-level knowledge dissemination and guide learners toward **in-depth analysis of complex issues, evidence-based argumentation, and critical reflection on technological ethics**. For example, debates on "designing natural species" encourage students to examine technological, ethical, and ecological dimensions from multiple perspectives.

2. Interdisciplinary Integration as a Driver of Innovation

University students have **accumulated knowledge across multiple disciplines**, making them well-suited to explore the intersections of different fields. By integrating synthetic biology with **AI, ethics, art, and global studies**, our activities—such as **AI-assisted "Beauty of Cells" art exhibitions and interdisciplinary roundtables**—enable students to transcend disciplinary silos, fostering innovative thinking that combines scientific rigor with artistic creativity, and technological optimism with ethical caution.

3. Cross-Cultural Collaboration and Global Perspectives

In an era of globalization, understanding diverse cultural perspectives on science and technology is essential for future leaders in synthetic biology. Our activities—such as cross-regional roundtables—**provide platforms** for students to exchange ideas with peers from different cultural backgrounds, learn about varying social attitudes toward synthetic biology, and **develop the ability to collaborate globally on scientific and social challenges**.

4. Practice-Oriented Learning and Professional Development

University students are preparing for future careers in science, technology, or related fields. Our activities—such as experimental summer camps and cutting-edge technology lectures—emphasize **hands-on experience, exposure to frontier research, and connections between academic knowledge and professional practice**. This not only deepens their understanding of synthetic biology but also equips them with practical skills and professional insights relevant to their future careers.

In essence, the guiding philosophy of this volume is to position university students as **emerging critical thinkers, interdisciplinary innovators, and global collaborators**. They are no longer passive recipients of knowledge but active participants who can analyze complex issues, reflect on ethical dilemmas, collaborate across cultures, and express scientific concepts creatively. By connecting synthetic biology to **real-world challenges and future career paths**, we ensure that their engagement with these fields is both **academically meaningful and professionally relevant**.

Educational Rationale: Understanding University Learners

Designing educational activities for university students requires recognition of their unique developmental profile. At this stage, young adults have reached Piaget's formal operational stage of cognitive development, enabling them to engage in abstract reasoning, hypothetical-deductive thinking, and systematic analysis of complex issues. They also have **well-developed social and emotional skills, with a growing sense of social responsibility and professional identity**. Activities must therefore be carefully tailored to leverage these strengths while addressing their specific learning needs.

1.Cognitive Development

According to **Jean Piaget's theory** of cognitive development, university students are in the **formal operational stage**. They can think abstractly, formulate hypotheses, test theories, and analyze complex systems without relying on concrete objects or experiences. This allows them to engage in in-depth debates on ethical issues in synthetic biology, understand the complex mechanisms of AI-synthetic biology integration, and design experimental protocols in summer camps. However, their learning still benefits from **connecting abstract theories to real-world applications**—for example, using case **studies of AI-assisted drug** development to **illustrate the practical value of interdisciplinary collaboration**.

2.Social Learning and Cross-Cultural Collaboration

Building on **Lev Vygotsky's sociocultural theory**, university students' learning is significantly enhanced by interactions with **peers, experts, and diverse cultural groups**. They thrive in collaborative environments that involve critical dialogue, interdisciplinary exchange, and cross-cultural communication. Activities such as **synthetic biology roundtables**—where students from different regions share perspectives on science and ethics—leverage these dynamics, enabling learners to co-construct knowledge while developing cross-cultural communication and collaboration skills essential for global scientific collaboration.

3.**Constructivist Learning and Lifelong Learning Orientation**

In line with **Jerome Bruner's constructivist perspective**, university students are capable of engaging with sophisticated, cutting-edge ideas—provided they are given opportunities to connect new knowledge to their existing cognitive frameworks. Through a **spiral curriculum**, concepts first introduced in primary or secondary school (such as basic cell structure or microbial function) are revisited in this volume with greater complexity (such as genetic engineering of cells or ethical implications of microbial applications). This staged revisiting ensures continuity and cumulative understanding, transforming fragmented knowledge into an integrated, flexible framework that supports lifelong learning—critical for adapting to rapid advancements in synthetic biology and related fields.

4.Ethical Development and Social Responsibility

University students are in a stage of ethical development where they begin to form **personal and professional ethics based on universal principles (such as justice, sustainability, and human dignity).** They are increasingly aware of the social impact of science and technology and feel a sense of responsibility to address these impacts. Activities such as debates on **"modifying natural species"** and **ethical discussions in roundtables** tap into this developmental stage, encouraging students to reflect on their role as future scientists, engineers, or leaders in ensuring that technology serves the greater good.

5. Professional Identity Formation

University is a key period for students to develop **professional identities.** They are exploring career paths in science, technology, art, or policy and seeking opportunities to apply their knowledge in professional contexts. Activities in this handbook—such as experimental summer camps that simulate real laboratory work, or lectures that highlight **career opportunities in synthetic biology and AI**—help students **connect their academic learning to professional practice**, fostering **a sense of purpose and direction in their career development**.

Anticipated Outcomes and Long-Term Impact

The activities documented in this volume are designed to produce outcomes that go beyond immediate academic engagement. They aim to contribute to university students' intellectual growth, professional development, and global awareness, while also ensuring a sustainable legacy for future iGEM teams and science educators.

1. Outcomes for Students

- **Enhanced Conceptual Understanding**

Students develop a deep, systematic understanding of synthetic biology and its interdisciplinary intersections (such as with AI, ethics, and art). Abstract concepts—such as CRISPR gene editing, AI-assisted protein structure prediction, and ethical frameworks for technological development—become meaningful through lectures, experiments, debates, and creative expression.

- **Cognitive and Critical Thinking Development**

Activities cultivate advanced cognitive skills, including critical analysis of complex issues (e.g., ethical dilemmas in synthetic biology), evidence-based argumentation (e.g., in debates), systems thinking (e.g., in experimental design), and interdisciplinary reasoning (e.g., integrating AI and synthetic biology).

- **Professional Skills and Competencies**

Students gain practical skills relevant to future careers, such as laboratory techniques (in experimental summer camps), cross-cultural communication (in roundtables), innovative expression (in AI art exhibitions), and ethical decision-making (in debates and discussions).

- **Global Awareness and Social Responsibility**

Through cross-cultural activities and ethical reflections, students develop a global perspective on synthetic biology—understanding how cultural, social, and policy contexts shape attitudes toward technology—and a sense of social responsibility to ensure that technology is used ethically and sustainably.

2. Outcomes for Universities and Academic Communities

- **Curriculum Enrichment**

The handbook provides universities with innovative, interdisciplinary activity models that can be integrated into formal curricula (such as biology, ethics, or art courses) or extracurricular programs (such as science clubs, debate teams, or art-science workshops), enriching the learning experience for students.

- **Fostering Interdisciplinary Collaboration**

Activities such as AI art exhibitions and interdisciplinary roundtables encourage collaboration between departments (e.g., biology, computer science, philosophy, and art), breaking down disciplinary silos and fostering a culture of interdisciplinary innovation within academic communities.

- **Enhancing University-Community Engagement**

Public activities—such as online AI art exhibitions or open debate sessions—enable universities to share cutting-edge scientific knowledge with the broader community, enhancing public understanding of synthetic biology and its implications.

3. Outcomes for the Educational System and Future Teams

- **Pedagogical Innovation**

The handbook demonstrates effective models of **university-level science education that emphasize critical thinking**, interdisciplinary integration, and ethical reflection—offering a framework that can be adapted by future iGEM teams, science educators, and educational institutions worldwide.

- **Continuity Across Educational Stages**

By building on primary school foundations (Volume 2) and preparing students for postgraduate study or professional careers, this volume contributes to a **spiral curriculum for lifelong science learning**, ensuring continuity in science education from early childhood to higher education and beyond.

- **Legacy and Transferability**

As part of a multi-volume series, this handbook ensures that our experiences, challenges, and solutions are **documented for replication**. Future teams can adapt the activities to different cultural, academic, or resource contexts—scaling them from small classroom workshops to large-scale international events (such as global roundtables or online art exhibitions).

- **Societal Impact**

By positioning university students as **critical thinkers, ethical leaders, and innovative creators**, the handbook nurtures a generation that will use synthetic biology and related fields to **address global challenges (such as climate change, food insecurity, and disease) while upholding ethical and sustainable principles**.

General Guidance for Activity Design

Before introducing specific activity blueprints, it is essential to articulate the principles and practices that should guide the design of educational activities for university students. These guidelines are informed by our practical experience, educational research, and the unique developmental characteristics of learners aged 18–25. They function as **actionable checkpoints** to ensure that each activity is not only engaging but also academically rigorous, ethically relevant, and adaptable to diverse contexts.

1.Academic Rigor and Intellectual Challenge

2.Ethical Relevance and Reflection

3.Interdisciplinary Integration

4.Practical Application and Hands-On Experience

5.Cross-Cultural and Inclusive Dialogue

6.Flexibility and Adaptability

7.Documentation and Feedback

Activity 1: *Lecture － When AI Meets Synthetic Biology*

Objective

To introduce university students to the intersection of synthetic biology and AI, highlighting how this interdisciplinary fusion accelerates scientific research (e.g., drug development, 新材料 creation) and to inspire their interest in cross-disciplinary learning and innovation.

Target Group

Ages 18–25; suitable for large lectures (50–200 students) or university-wide science events.

Materials Needed

- Projector and large screen for slides and video demonstrations
- Tri-fold brochures introducing key concepts (e.g., CRISPR, BioBricks, AI protein structure prediction)
- Animated videos (e.g., AlphaFold’s protein structure prediction process)
- Microphones for Q&A sessions

Procedure

- **Introduction (15 min):** Open with an overview of synthetic biology as the "third biological revolution" and AI as the "core engine of the fourth industrial revolution," emphasizing the transformative potential of their intersection.
- **Key Concept Explanation (25 min):** Explain core concepts in synthetic biology (CRISPR, BioBricks) and AI (machine learning, AlphaFold), using simple language and visual aids to clarify complex mechanisms.
- **Case Studies and Demonstrations (20 min):** Present real-world case studies (e.g., AI-assisted drug development, metabolic pathway optimization) and show animated videos (e.g., how AlphaFold reduces years of experimental work to hours).
- **Team Project Sharing (15 min):** Share the team’s own projects involving AI and synthetic biology, providing practical examples of how these fields can be integrated.
- **Q&A and Discussion (15 min):** Invite students to ask questions about technical implementation, application scenarios, or ethical implications, fostering in-depth dialogue.

Learning Outcomes

- Understand the core concepts of synthetic biology and AI, and their interdisciplinary applications.
- Recognize how AI accelerates key processes in synthetic biology (e.g., protein structure prediction, metabolic pathway optimization).
- Develop interest in cross-disciplinary learning and begin to consider their potential role in this field.

Reflections & Recommendations

• University students are highly interested in cutting-edge technical applications; incorporating more real-world case studies can enhance engagement.

•Pair this lecture with hands-on activities (e.g., AI art workshops or experimental camps) to deepen understanding of theoretical concepts.

Activity 2: *Experimental Summer Camp*

Objective

To bridge the "practice gap" for university students by providing hands-on laboratory experience in synthetic biology, allowing them to observe, extract, understand, and apply key biological processes (e.g., cell structure observation, DNA extraction, fluorescent gene expression simulation).

Target Group

Ages 18–25; suitable for small groups (15–30 students) with basic biological knowledge; ideal for biology majors or students interested in life sciences.

Materials Needed

- Laboratory equipment (microscopes, centrifuges, pipettes, Petri dishes)
- Experimental materials (onion samples for cell observation, cheek cell samples for DNA extraction,
- fluorescent proteins for gene expression simulation)
- Safety equipment (lab coats, gloves, goggles)
- Worksheets for recording experimental procedures and results

Procedure

- **Pre-Camp Preparation (30 min)**: Conduct a safety briefing on laboratory rules, equipment use, and experimental protocols, and review basic biological concepts (e.g., cell structure, DNA properties).
- **Onion Epidermal Cell Observation (60 min)**: Guide students to prepare onion epidermal samples, stain them, and observe cell walls, nuclei, and cytoplasm under a microscope; ask them to sketch and label the structures.
- **DNA Extraction from Cheek Cells (90 min)**: Walk students through the process of extracting DNA from their own cheek cells (using lysis buffer, ethanol precipitation), allowing them to "touch" and observe DNA; explain the biological principles behind each step.
- **Fluorescent Gene Expression Simulation (90 min)**: Demonstrate how to transfect cells with fluorescent protein plasmids, and guide students to observe fluorescent signals under a UV microscope; discuss the applications of gene expression in synthetic biology.
- **Debriefing and Reflection (30 min)**: Have students share their experimental findings, discuss challenges encountered, and reflect on how the experiments connect to theoretical knowledge of synthetic biology.

Learning Outcomes

- Master basic laboratory techniques in synthetic biology (e.g., cell observation, DNA extraction, gene expression simulation).
- Connect theoretical knowledge of biology (e.g., cell structure, DNA properties) to practical experimental processes.

- Develop scientific inquiry skills, including experimental design, data recording, and problem-solving.

Reflections & Recommendations

- Students value hands-on laboratory experience; ensuring sufficient equipment and one-on-one guidance can enhance the learning experience.
- Incorporate more advanced experiments (e.g., CRISPR gene editing simulations) for students with higher-level biological knowledge to meet diverse learning needs.

Activity 3: *Debate － Should Humans Massively Design or Modify Natural Species Through Synthetic Biology?*

Objective

To provide university students with a platform for in-depth speculation on the core ethical and social issues of synthetic biology, fostering their ability to analyze complex issues from multiple perspectives, construct evidence-based arguments, and engage in rational dialogue.

Target Group

Ages 18–25; suitable for debate teams (8–12 debaters) and audience members (50–100 students); ideal for students interested in biology, ethics, law, or public policy.

Materials Needed

- Debate format guidelines (e.g., opening statements, rebuttals, free debate, closing arguments)
- Reference materials (scientific papers on synthetic biology applications, ethical frameworks, case studies of ecological risks)
- Podiums, microphones, and a timer for the debate
- Scorecards for judges (professors from biology, philosophy, or law departments)
- Name tags for debaters and judges

Procedure

- **Debate Preparation (2 weeks in advance):** Divide students into pro and con teams; provide them with reference materials on synthetic biology applications (e.g., crop improvement, disease treatment) and risks (e.g., ecological disruption, ethical 滑坡); ask teams to prepare arguments and evidence.
- **Opening Session (30 min):** Introduce the debate topic, debaters, judges, and format; have each team deliver a 10-minute opening statement outlining their core arguments (pro: emphasizing solutions to global challenges; con: highlighting ethical and ecological risks).
- **Rebuttal Session (20 min):** Each team delivers a 10-minute rebuttal, challenging the opponent's arguments and reinforcing their own with additional evidence.
- **Free Debate (40 min):** Allow teams to engage in dynamic dialogue, asking questions, refuting claims, and defending their positions; encourage in-depth exchange on key issues (e.g., risk assessment, ethical boundaries, public consent).
- **Closing Statements (20 min):** Each team delivers a 10-minute closing statement, summarizing their key arguments and addressing the opponent's main challenges.
- **Judge Evaluation and Feedback (30 min):** Judges score the teams based on argument strength, evidence use, logical coherence, and rebuttal effectiveness; provide constructive feedback on debate

skills and content depth.

- **Audience Discussion (20 min):** Invite audience members to ask questions of the debaters or share their own perspectives, expanding the dialogue beyond the debate teams.

Learning Outcomes

- Analyze the ethical, ecological, and social implications of synthetic biology from multiple perspectives.
- Construct evidence-based arguments and engage in rational, respectful debate on complex issues.
- Develop critical thinking skills, including identifying logical fallacies, evaluating evidence, and synthesizing diverse viewpoints.

Reflections & Recommendations

- Inviting professors from multiple disciplines (biology, ethics, law) as judges enriches the evaluation perspective and provides students with comprehensive feedback.
- Extend the debate topic to related issues (e.g., "Should AI be used to design synthetic organisms?") to explore broader interdisciplinary questions.

Activity 4: *Synthetic Biology Roundtable*

Objective

To create a cross-regional, interdisciplinary platform for university students to exchange perspectives on synthetic biology—including cultural attitudes, ethical concerns, and educational practices—fostering their cross-cultural communication skills and global awareness of synthetic biology development.

Target Group

Ages 18 – 25; suitable for students from different regions (domestic or international) and disciplines (biology, ethics, education, policy); ideal for small groups (15 – 25 participants) to facilitate in-depth dialogue.

Materials Needed

- Online meeting platform (e.g., Zoom, Teams) for cross-regional participation (or physical meeting space for in-person roundtables)
- Discussion guides with key topics (e.g., regional differences in public acceptance of synthetic biology, effective science communication strategies)
- Presentation slides (for sharing regional data or case studies)
- Recording equipment (to document the discussion for future reference)
- Note-taking templates for participants

Procedure

- **Preparation (1 month in advance)**: Invite students from different regions (e.g., China, North America, Europe) and disciplines; share discussion topics and ask participants to prepare short presentations on their region's attitudes toward synthetic biology or relevant case studies.
- **Opening (20 min):** Welcome participants; introduce the roundtable's purpose (cross-cultural exchange on synthetic biology) and format (presentations + guided discussion); set ground rules for respectful dialogue.
- **Regional Presentations (60 min)**: Each participant delivers a 5 – 10 minute presentation on their region's cultural, social, or policy context related to synthetic biology (e.g., public acceptance of GMOs, educational programs in synthetic biology); use slides to illustrate key points.
- **Guided Discussion (90 min)**: Facilitate discussion on key topics using the discussion guide:

  How do cultural values (e.g., views on "nature," collective vs. individual interests) shape attitudes toward synthetic biology?

  What are the most effective ways to communicate synthetic biology to the public in different regions?

  How can we collaborate across regions to address global challenges using synthetic biology (e.g., climate change, pandemic response)?

- **Summary and Action Planning (30 min)**: Summarize key insights from the discussion (e.g., common challenges, regional differences); invite participants to propose ideas for future cross-regional collaboration (e.g., joint research projects, shared educational resources).
- **Follow-Up (1 week after)**: Share a recording of the roundtable and a summary document with participants; encourage continued communication and collaboration.

Learning Outcomes

- Understand how cultural, social, and policy contexts shape regional attitudes toward synthetic biology.
- Develop cross-cultural communication skills, including active listening, respectful dialogue, and adaptation to diverse perspectives.
- Identify opportunities for cross-regional collaboration in synthetic biology education, research, or public engagement.

Reflections & Recommendations

- Providing discussion guides in advance helps participants prepare and ensures focused, productive dialogue.
- Combining in-person and online participation (hybrid format) can expand the range of regional perspectives while accommodating logistical constraints.

Activity 5: *"Beauty of Cells" AI Interactive Art Exhibition*

Objective

To break down the traditional boundaries between science and art, allowing university students to reimagine synthetic biology concepts (e.g., cell structure, DNA, gene editing) through AI-assisted art, and to communicate scientific beauty to a broader audience.

Tatget Needs

College students of all majors (with a focus on art, design, and life science majors); suitable for exhibition and workshop activities (50–80 participants in the workshop, open to all students for the exhibition).

Materials Needed

- AI art tools (e.g., DALL-E, MidJourney, Stable Diffusion)
- Tutorial materials for AI art creation (e.g., guides on writing effective prompts, adjusting parameters)
- Reference materials on biological concepts (e.g., diagrams of mitochondria, DNA double helix, CRISPR mechanism)
- Digital display platforms (e.g., university website, social media, online galleries) or physical exhibition space (for printed artworks)
- Labels for artworks (including creator name, AI prompt, and a brief explanation of the scientific concept)
- Workshops space with computers (for in-person AI art creation)

Procedure

- **AI Painting Workshop (1 day, 6 hours total)**:
- **Science Concept Introduction (60 min)**: Invite life science teachers to explain core biological concepts (e.g., the structure and function of mitochondria) and their visual characteristics.
- **AI Tool Training (90 min)**: Guide students to learn the basic operation of AI painting tools, and teach them how to convert scientific terms into vivid artistic prompts (e.g., "DNA double helix shining in the cosmic-like cell" instead of "DNA structure").
- **Independent Creation (180 min)**: Students create AI artworks based on the scientific concepts they have learned, with tutors providing one-on-one guidance on prompt optimization.

- **Work Review (30 min)**: Invite students to share their creation ideas and artworks, and conduct peer reviews to select excellent works.
- **Art Exhibition (lasting 1 week, including online and offline displays)**:
- Exhibition Setup: Arrange excellent works in the offline exhibition hall (with exhibition labels) and launch the online gallery (supporting artwork browsing and comment interaction).
- **Opening Event (60 min)**: Host introduces the concept of the exhibition ("integrating science and art to discover the beauty of life"), and invites representative creators to share their creation experiences.
- **Exhibition Period**: Maintain the offline exhibition hall and update online comments; organize a closing summary session to collect visitors' feedback.
- **Post-Exhibition Promotion**: Compile the activity plan, AI painting tutorials, and selected prompts into an open-source "Science-Art Integration Toolkit" and share it with iGEM teams and educators.

Learning Outcomes

- Translate complex synthetic biology concepts into creative, visual art using AI tools.
- Develop interdisciplinary thinking that combines scientific rigor with artistic creativity.
- Improve science communication skills by explaining scientific concepts to a non-expert audience through art.

Reflections & Recommendations

- Students from non-science backgrounds (e.g., art, design) bring unique creative perspectives; actively recruiting them ensures diverse artworks and broader audience appeal.
- Compiling selected artworks, AI prompts, and scientific explanations into a digital booklet (shared online) extends the exhibition's impact beyond its duration.

Activity 6: Northeast China iGEMer Exchange Meeting

Objective

Break geographical barriers, build a cross-university cooperation platform for iGEM teams in Northeast China, enable students to conduct in-depth dialogue on cutting-edge issues of synthetic biology, share project experience, technical methods, and resource channels, and promote the collaborative development of iGEM forces in the region.

Target Group

iGEM team members from colleges and universities in Northeast China; suitable for large-scale exchange meetings (150–200 participants).

Materials Needed

- Venue equipment (projectors, microphones, and podiums for the main forum and parallel seminar rooms)
- Lecture handouts (including annual iGEM competition trends and synthetic biology ethical review standards)
- Project plan polishing templates and discussion guides (for the afternoon seminar)
- Name tags and meeting handbooks (for recording key points of the meeting)

Procedure

- **Morning Main Forum (180 min, held in Dongrong Lecture Hall, Qianwei South Campus of Jilin University)**:
- **Opening Ceremony (20 min)**: The host introduces the purpose of the meeting ("synthesis and co-development — weaving the scientific research star network in Northern China") and the agenda.
- **Keynote Speeches (120 min)**: Invite senior iGEM instructors to interpret the annual competition trends and ethical review standards; arrange outstanding previous teams to share the complete process of project selection and implementation.
- **Question & Answer (40 min)**: Students ask questions about the speeches, and instructors and team representatives answer them.
- **Lunch Break & Free Communication (60 min)**: Provide time for students from different teams to communicate freely and exchange contact information.

- **Afternoon Parallel Seminars (150 min, held in the Lecture Hall on the Second Floor of the Basic Medical College, Xinmin Campus of Jilin University)**:
- Divide into three groups according to "medical and health", "environmental governance", and "agricultural innovation" to carry out discussions.
- Each group focuses on technical bottlenecks (e.g., gene vector optimization) and project HP design difficulties, and conducts project plan polishing under the guidance of tutors.
- **Closing Summary (30 min)**: Summarize the key results of the exchange meeting, share the resource sharing intentions reached by each team, and announce the follow-up cooperation plans.

Learning Outcomes

- Understand the cutting-edge trends of synthetic biology and iGEM competitions, and master practical experience in project design and implementation.
- Establish connections with iGEM teams in other universities in Northeast China, and reach resource sharing intentions (e.g., experimental reagent mutual assistance, joint data analysis).
- Realize the importance of combining regional characteristics (e.g., cold region ecological protection) with synthetic biology projects, and expand the thinking of project localization design.

Reflections & Recommendations

- The two-stage structure of "main forum + parallel seminars" effectively balances the breadth and depth of the exchange; this model can be retained in future activities.
- Some teams face shortages in experimental equipment and cutting-edge technology access; it is necessary to build a regional iGEM resource sharing platform to solve this problem.

Activity 7: *Joint Team Online Synthetic Biology Popular Science Lecture for College Students*

Objective

Break the limitations of time and space, provide college students (especially those in remote areas) with a zero-threshold opportunity to access synthetic biology, popularize core concepts of synthetic biology, and stimulate students' interest in interdisciplinary scientific research.

Target Group

College students of all majors; suitable for online large-scale lectures (1000–1500 participants).

Materials Needed

- Online live broadcast platforms (e.g., Tencent Meeting, Bilibili Live)
- Illustrated slides and short videos (for explaining synthetic biology concepts and project cases)
- Learning resource packages (including recommended introductory books and online course links)
- Online question collection forms and interactive comment areas (for Q&A sessions)

Procedure

- **Pre-Lecture Promotion (1 week in advance)**:
- Release lecture previews through university student unions and club channels, and post graphic "synthetic biology tips" posters to attract students' attention.
- Test the online live broadcast platform to ensure smooth audio and video transmission, and open the pre-registration channel.
- **Lecture Session (150 min)**:
- **Basic Popular Science (40 min)**: Biology teachers use plain language to explain core concepts of synthetic biology (e.g., gene editing, biosynthetic pathways) and eliminate the sense of distance from "hardcore science".

- **Cutting-Edge Case Sharing (50 min)**: iGEM team members from various universities share practical project cases (e.g., "microbial synthesis of biodegradable plastics") and tell stories about overcoming difficulties in the research process.

- **Interactive Q&A (60 min)**: Teachers and team members jointly answer students' questions about "major selection", "scientific research entry", and "application prospects of synthetic biology" through the comment area and question collection forms.

- **Post-Lecture Follow-Up (3 days later)**:

- Release the lecture replay on the live broadcast platform, and send the learning resource package to registered students via email.

- Collect students' feedback on the lecture and sort out common questions for follow-up answers.

Learning Outcomes

- Establish a clear recognition of synthetic biology, and eliminate the misunderstanding that it is "unreachable".

- Understand the application scenarios of synthetic biology in daily life, and stimulate interest in interdisciplinary scientific research.

- Obtain practical learning resources for synthetic biology, and clarify the direction of further study or participation in scientific research.

Reflections & Recommendations

- The dual-platform live broadcast mode expands the coverage of the lecture; it is recommended to continue to use this mode to reach more students.

- Some students reflect that "lack of practical experience makes it difficult to understand abstract concepts"; it is necessary to launch a series of "synthetic biology micro-class" short videos to supplement and explain key knowledge points.

Activity 8: *Humanism in Science: Concept and Implementation*

Objective

Guide college students to think about the humanistic value of scientific research and the ethical boundaries of technological application, cultivate scientific researchers with both scientific literacy and humanistic spirit, and promote the integrated development of science and humanities.

Target Group

College students of all majors (with a focus on life sciences, philosophy, and sociology); suitable for online and offline hybrid activities (250 – 300 participants).

Materials Needed

- Venue equipment (offline main venue: lecture hall with projection and video recording functions; online platform: Tencent Meeting)
- Case materials (e.g., reports on "gene-edited babies" and "synthetic microbial ecological release")
- Role-playing scripts (for "researchers", "ethicists", "public representatives", and "policymakers")
- Discussion guides and feedback forms

Procedure

- **Theme Speech (60 min)**:

  Invite philosophy professors to give a speech on "the core connotation of scientific humanism", sort out the relationship between science and humanities from a historical perspective, and analyze the importance of "technology for good" combined with synthetic biology cases.

- **Case Discussion (60 min)**:

Divide students into online and offline groups, provide real cases of synthetic biology, and guide them to discuss "standards for scientific research ethics review" and "assessment of social impacts of technology application".

• **Role-Playing (90 min)**:

Students play different roles ("researchers", "ethicists", "public representatives", "policymakers") and conduct a simulated debate on "whether to promote synthetic biology-modified food crops".

After the role-playing, each group sends a representative to share the insights gained from the perspective of their role.

• **Summary & Feedback (30 min)**:

The host summarizes the key viewpoints of the activity, emphasizes the importance of integrating humanism into scientific research, and distributes feedback forms to collect students' opinions.

Learning Outcomes

• Understand the core connotation of scientific humanism, and establish the awareness that "scientific research should not only pursue truth but also goodness".

• Master the method of analyzing the social and ethical impacts of scientific and technological projects from multiple perspectives.

• Cultivate the sense of responsibility of scientific researchers, and realize the need to consider humanistic factors in the process of technological research and development.

Reflections & Recommendations

• The role-playing link effectively enhances students' sense of participation and understanding of different perspectives; it is necessary to optimize the script design to make the role settings more detailed.

• Some students lack knowledge of "specific humanistic practice methods"; it is planned to compile the "Handbook of Humanistic Care in Scientific Research" to provide practical operation guidelines.

Reflection and Evolution

This volume reflects our collective effort to **translate cutting-edge, interdisciplinary concepts** (synthetic biology, AI, ethics, art) into engaging and meaningful educational activities for university students. Through activities ranging from lectures on technological intersections to cross-cultural roundtables and AI art exhibitions, we witnessed university students' remarkable ability to **move beyond theoretical knowledge acquisition to in-depth critical thinking, ethical reflection, cross-cultural collaboration, and innovative expression**.

Our reflections highlight several key insights:

1. **Interdisciplinarity as a Catalyst for Engagement**

   University students respond strongly to activities that break down disciplinary silos. For example, the "Beauty of Cells" AI art exhibition attracted students from art, design, and computer science—fields not traditionally associated with synthetic biology—demonstrating that interdisciplinary fusion not only enriches learning but also expands the reach of science education.

2. **Ethical Reflection as a Driver of Depth**

   Activities that address ethical issues (such as the debate on modifying natural species) pushed students to go beyond surface-level technical understanding and engage with the broader social implications of synthetic biology. Their questions about risk assessment, public consent, and equity revealed a strong sense of social responsibility—a key strength to leverage in future activities.

3. **Cross-Cultural Exchange as a Tool for Global Awareness**

   The synthetic biology roundtable showed that university students benefit greatly from exposure to diverse regional perspectives. For example, discussions on cultural attitudes toward "nature" and "technology" helped students recognize that there is no single "right" approach to synthetic biology development—fostering empathy and global collaboration skills essential for future leaders.

4. **Practice-Oriented Learning as a Bridge to Professionalism**

   Experimental summer camps were particularly impactful for students interested in scientific careers. Hands-on experience with DNA extraction and fluorescent gene expression not only deepened their understanding of synthetic biology but also gave them practical skills that are relevant to laboratory work and future employment.

Looking ahead, this handbook should not be viewed as a static compilation but as a **living framework for iterative innovation**. Future teams are encouraged to:

- **Expand Interdisciplinary Depth**: Explore more intersections of synthetic biology with emerging fields (e.g., quantum computing for biological simulation, synthetic biology in space exploration) to keep activities at the cutting edge of technological development.

- **Strengthen Industry-Academia Collaboration**: Partner with biotech companies, AI startups, or ethical think tanks to provide students with access to real-world professionals and projects—bridging the gap between academic learning and industry practice.
- **Enhance Digital and Global Accessibility:** Develop online versions of activities (e.g., virtual experimental simulations, global online roundtables) to reach students in regions with limited resources or access to in-person events.
- **Incorporate Longitudinal Assessment**: Design tools to track the long-term impact of activities (e.g., surveys of students' career choices, follow-up interviews on their ethical perspectives) to evaluate how effectively the handbook supports lifelong learning and professional development.
- **Empower Student Leadership**: Provide opportunities for university students to co-design and lead future activities—transforming them from participants to educators and ensuring that **activities remain responsive to their needs and interests**.

Ultimately, the evolution of this handbook mirrors the learning journey of university students themselves: **iterative, adaptive, and focused on growth**. By grounding synthetic biology education in interdisciplinarity, ethical reflection, cross-cultural collaboration, and practice, we have laid a foundation for learners who will not only advance scientific knowledge but also use it to **address global challenges and shape a more ethical, sustainable future**.