Restructuring a lecture from the Bioinformatics 1 Course to respect the TDS model

Dhouha Grissa

Department of Veterinary and Animal Sciences

University of Copenhagen

Course description

The Bioinformatics 1 course is a yearly Bachelor course, provided by The Faculty of Natural and Life Sci- ences for Bachelor students from the biotechnology and molecular biomedicine programs, and for people who seek further and continuing education. The course is offered during 1 block and is given every week with an average of 2-3 double lectures. We, teachers are from different teams and institutes, Department of Plant and Environmental Science, Department of Veterinary and Animal Sciences (IVH), and Chemical In- stitute. Each team collaborates to prepare their part of the teaching course. Then group leaders communicate together for harmonization and congruence purposes.

The Bioinformatics 1 course aims to provide students with a solid foundation in basic digital bioinfor- matics methods and their applications. It covers various topics, including molecular and protein structure databases, sequence alignments, RNA and transcriptomics, genome annotation, and more. The course em- phasizes hands-on experience with bioinformatics tools and a critical understanding of underlying principles. By the end of the course, students are expected to possess the knowledge and skills necessary for analyzing biological data and critically evaluating results obtained using bioinformatic methods. As a teacher in this course, I am involved in the part related to molecular structure and RNA, where my role is to give a lecture and help students with exercises.

Problem identification and goal of the intervention

This pedagogical project aims to address the challenges stemming from a lack of activities and interaction in the lecture setting, thereby fostering a transition from a content-oriented (teacher-centered) to a learning-oriented (student-centered) approach in the Bioinformatics course (Vygotsky, 1978). The overarching objective is to im- plement interactive classes that enhance students' learning, participation, and engagement (Freeman, Eddy, McDonough, Smith, Okoroafor, Jordt & Wenderoth, 2014).

Specifically, the project seeks to achieve the following goals:

- Integrate activation techniques, such as questions and discussions, into the traditional PowerPoint (PPT) format to transform the class into a more interactive learning environment.
- Facilitate debates and group work to promote increased participation and engagement among students.
- Illustrate how these teaching strategies have the potential to enhance the overall learning atmosphere of the Bioinformatics course.

The identified problem lies in the absence of diverse activities and interaction during the lectures, hin- dering students' engagement with the course material. To address these challenges, my objective is to reorganize the course by aligning it with the TDS model (Devolution-Activation-Formulation-Validation- Institutionalization) (Brousseau, 1997). This restructuring aims to create a seamless progression of learning phases and ensure consistent student engagement throughout the course through the incorporation of impactful and con- tinuous learning activities.

Several reasons motivated my decision to initiate this course reorganization:

- Bioinformatics 1 is designed as an intensive program for a diverse group of students with varied back- grounds, covering numerous intriguing topics. However, the abundance of information can overwhelm students, hindering their ability to fully comprehend and retain key concepts.

- The hands-on exercises provided pose challenges, as students often struggle to apply theoretical knowl- edge gained from lectures to practical applications. This difficulty arises from either missing funda- mental lecture notions or a lack of thorough comprehension of underlying principles.
- In my view, the current format of the course, while informative, is lacking in opportunities for students to actively apply and discuss the introduced concepts and models during lectures. Such activities are currently confined to separate exercise sessions, limiting the potential for immediate clarification and deeper understanding. The TDS framework offers a compelling solution to bridge this gap. By incorporating elements of this model into lectures, we can create engaging and continuous activities that promote student participation and deepen their understanding.

Unintentionally, this absence of pedagogical elements creates an environment where some students resort to chatting and disrupting the class. In my efforts to restructure the lecture, I have focused on aligning with the TDS framework, emphasizing good activities that support student learning. This involves a meticulous consideration of intended learning outcomes (ILOs), designing student activities to achieve these outcomes, and incorporating TDS phases into the planning process: Devolution, Action+Formulation, Validation, and Institutionalization.

Description of my teaching experiment

The objective of my teaching experiment was to enhance engagement and learning in the bioinformatics course, which covers fundamental digital bioinformatics methods and practical applications. The intensive nature of the course often overwhelms students, making it challenging for them to fully grasp and retain key concepts.

Redesigning the teaching session

To tackle the aforementioned issue, I focused on the computational and comparative genomics topic. The teaching session redesign involved restructuring the lecture to be more interactive, with activities strategically interspersed every 10 to 15 minutes. I followed the Theory of Didactic Situations (TDS) model, introducing concepts sequentially, engaging students in activities, and facilitating validation through peer feedback (Hattie & Timperley, 2007). Table 1 provides a comprehensive overview of the teaching session's planning.

A week before the lecture, reading materials were distributed, including PowerPoint slides and papers (Herskin, 2001). The use of handouts was debated, with advantages such as time-saving and disadvantages like hin- dering note-taking skills. At the beginning of the session, I outlined the learning outcomes and introduced computational genomics, encouraging discussions with real-life examples. For the extensive topic of genome annotation, two activities were incorporated, promoting collaborative learning (Chiriac & Hempel, 2005; Christensen, 2006).

Table 1: Teaching Session Planning for the Bioinformatics Course.

Session theme: Introduction to computational genomics		
Learning Objectives	**Student activities in the session**	**Tools of understanding / Materials**
Understand what computational genomics is.	**Open discussion** with your neighbour	Understanding students' existing knowledge of the topic through providing real- life examples.
Acquire knowledge about genome annotation.	**Group work** - discuss within a group of 2 to 4 students the function of a gene and its evolution. **Active reflection** - Students should take a moment to consider their response to a given question. Following this reflection, they are encouraged to actively engage with their peers by sharing and discussing their ideas with neighbors.	Students are expected to read designated book chapters, and online resources independently before the session, and follow the PPT slides to enhance their understanding.
Define a gene and explore its land- scape.	**Quizz** about gene definition.	Research paper to read individually before the session.
Gain basic knowledge about com- parative genomics.	**Open discussion** about what comparative genomics could address.	Small introduction to the topic using PPT slides.
Peer feedback	Use the provided padlet link to document any challenging concepts or questions encountered during the session. Encourage students to actively engage with their peers by responding to questions or offering constructive feedback on classmates' posts.	

Activation techniques

Adopting a student-centered approach, I integrated various activities to maintain engagement. Interactive exercises were embedded within the lecture, encouraging participation by posing questions every 10 minutes.

Collaborative learning and interaction Two group-based activities with 2 to 4 participants were introduced, fostering collaboration, discussions, and shared perspectives. The first activity required small groups of approximately four students to engage in a detailed discussion on a specific aspect of genome annotation, promoting collaborative learning. The second activity encouraged individual reflection, followed by peer discussion. For both activities, we collectively shared their insights, and I further clarified the introduced concepts, either on the blackboard or through a PowerPoint slide.

Quizzes Engaging quizzes that focus on student-centered learning and incorporating real-world Examples were planned during the lecture to maintain students' attention and provide follow-up interaction that illus- trates complex concepts effectively. However, as the lecture progressed, time constraints became a constraint, compelling me to decide on the final planned activity for the last topic of the lecture. I chose to proceed with the lecture rather than introducing the originally planned quiz activity. To encourage participation and provide a platform for questions and key takeaways, I introduced a Padlet link for students. Regrettably, no students utilized this tool.

Integrating Theory of Didactic Situations (TDS) Model in My Teaching Session

When planning my teaching session, I used the Theory of Didactic Situations (TDS) model as a guide. It helped structure the activities by following key steps: Devolution, Activation, Formulation, Validation, and Institutionalization.

Devolution: Providing reading and online materials before the session to encourage self-directed learning. Introducing and explaining concepts before activities, gradually shifting the responsibility for learning to students.

Activation: Open discussion with peers to stimulate thinking and prepare for upcoming content. Engaging in group work to collaboratively understand the function of a gene and its evolution. The idea of conducting a quiz about gene definition to activate prior knowledge. Facilitating an open discussion about what comparative genomics could address.

Formulation: Encouraging group discussions to actively construct knowledge about gene function and evolution.

Validation: Active reflection on given questions, followed by peer discussions to validate and refine ideas. Reviewing quiz answers and discussing correct solutions to validate understanding. Summarizing key points from group discussions to validate formulated knowledge.

Institutionalization: Providing summaries or insights after open discussions and group activities. Rein- forcing correct answers after quizzes to institutionalize understanding. Concluding with a class discussion to consolidate learning, address misconceptions, and solidify knowledge.

This pedagogical approach reflects a thoughtful integration of TDS, fostering a student-centered learning environment where the gradual transition of responsibility promotes engagement, collaboration, and the long- term retention of knowledge.

Teaching with TDS: A Practical Example in My Classroom

Table 2 illustrates one of the TDS-based activities (activity 2) that I designed and structured within the frame- work of the Bioinformatics course.

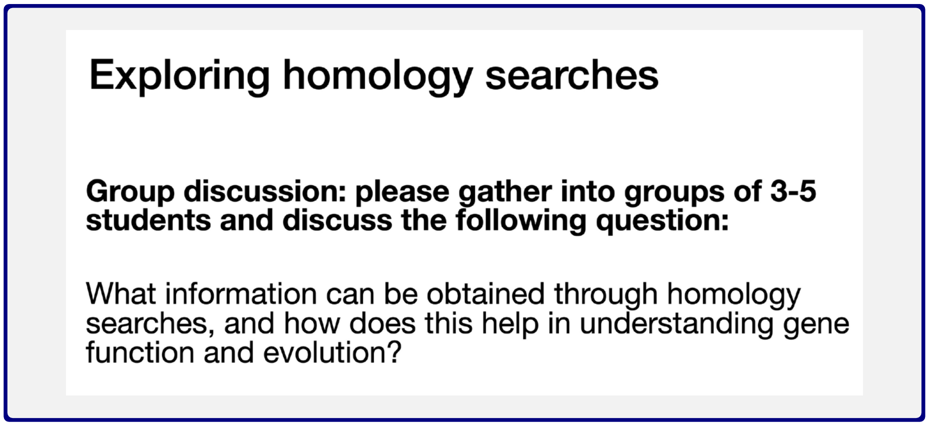

Fig 1: The second reflection activity focuses on introductory questions related to a key aspect of functional genome annotations—the homology search. The students were asked to discuss the provided questions and collectively formulating well-developed answers.

Table 2: Implementation of TDS-Based Activity in the Bioinformatics Course: Activity 2 Overview

TDS model	Description
Activity	The students were separated into small groups of 3 to 5 to engage in discussions on introductory questions about homology search, a key strategy in functional genome annotation.
Devolution	The activity was introduced using an in-class presentation slide, which is avail- able in Figure 1 for reference.
Action/formulation	Students actively engaged in the task, fostering collaboration through discus- sions on various questions. They worked together to formulate responses to the provided questions within their respective groups. Overall, the students exhib- ited effective performance, showcasing robust teamwork skills.

Validation	I facilitated the validation process by allocating 2 minutes for group discus- sions. Following this, I invited volunteers from various groups to present their answers to the class, promoting knowledge sharing and participation. I ac- tively engaged with the students by transcribing their key responses on the blackboard, providing a visual reference for the entire class. Additionally, I encouraged further elaboration to consider alternative viewpoints by asking follow-up questions and seeking opinions from their peers. This interactive ap- proach ensured that students were not just learning, but actively participating in the process.
Institutionalization	I institutionalized the feedback by preparing a PowerPoint slide (Figure 2) con- taining responses to the provided questions. This slide served several purposes. First, it reinforced student understanding and correctness by highlighting areas where their responses aligned with the presented information. Additionally, I provided additional explanations and addressed any areas that might have been unclear. Finally, the slide served as a springboard for further discussion, as I encouraged students to ask any remaining questions to ensure complete clarity on the concepts covered.

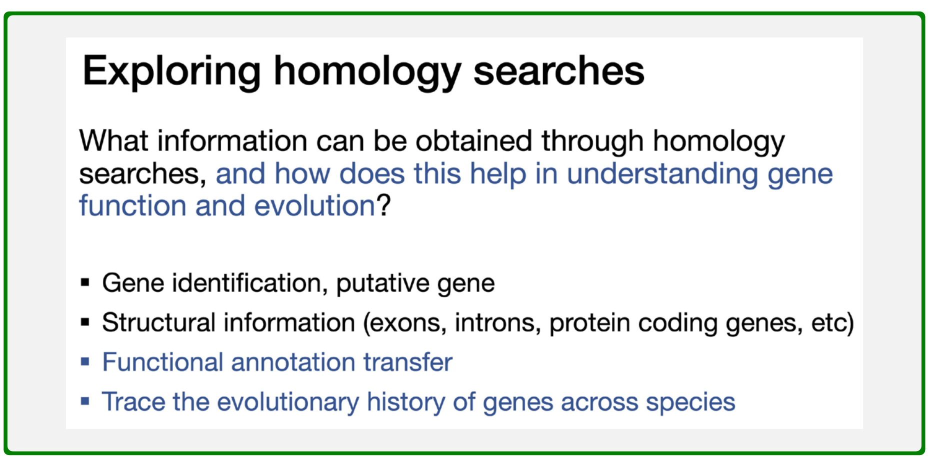

Fig 2: Institutionalization Snapshot: PowerPoint slide featuring varied responses to the provided introductory questions on homology search for functional genome annotation.

Theoretical exercises

After the lecture, a set of more intricate theoretical exercises was presented to the students. Alongside two colleagues, I assisted students in resolving these problems during a dedicated session. While some students preferred individual work, the majority collaborated in groups of 2 to 4. During this collaborative session, my focus was on fostering discussions within the groups, aiming to comprehend the specific challenges or concepts that remained unclear to them, rather than simply providing direct answers.

To facilitate a deeper understanding, I actively engaged with the groups, walking around and attentively listening to their discussions. I encouraged students to articulate their thoughts and, at times, offered key-words to prompt their thinking, aiming to activate their problem-solving abilities. Additionally, I made it a point to inquire if further assistance was needed, or I patiently waited until someone sought help.

Recognizing the importance of allowing students sufficient time for independent thought, I adopted a facilitative role by providing hints or keywords instead of immediate solutions. For those struggling to find the correct answers, I took the opportunity to thoroughly explain the problem, guiding them through the for- mulation, validation, and institutionalization of the underlying concepts embedded in the given question or exercise. This approach aimed to empower students to think critically, reinforcing a comprehensive under- standing of the material rather than simply providing quick solutions.

Personal reflections

Reflecting on my first experience teaching in Bioinformatics course, I encountered several challenges, pri- marily due to my limited knowledge of the subject matter and the need to adhere to predetermined course material. While it presented difficulties, there were notable successes in my teaching approach.

One aspect that contributed to a positive learning environment was the early distribution of teaching materials, providing students with the opportunity to review and engage with the content in advance. This proactive approach encouraged active participation during the lecture. I was pleased to observe that the students displayed a high level of attentiveness and interest throughout the session. My adoption of a student- centered approach, following the TDS model, played a significant role in maintaining their engagement. By incorporating diverse activities, including open discussions, individual reflections with peer feedback, and group-work discussions, I managed to sustain their focus. I also allowed adequate time for each activity, fostering a dynamic and interactive atmosphere. However, there are areas for improvement. The quality of activities could be enhanced by introducing peer feedback between groups and promoting deeper discussions. Additionally, I could have dedicated more time to addressing activity-related concepts, allowing students further opportunities to share their insights and ideas. In terms of managing time, it was a notable weakness in my teaching. I found myself running out of time, which created stress and disrupted the planned lecture progression. While it was a difficult decision, I had to skip one activity to ensure we covered essential content. Technical aspects also posed some challenges. Some students at the back of the room had difficulty hearing me. Furthermore, a few slides contained excessive text, making them challenging to read, and my writing on the blackboard was too small. Language barriers affected my ability to understand and interact effectively with students who spoke different languages.

Future directions and areas of improvements

Reflecting on the comprehensive experience gained in this project, it is imperative to chart a course for future enhancements in the Bioinformatics course, emphasizing continuous engagement with both students and co-teachers. Moving forward, I envision implementing targeted strategies to optimize the learning experience. To streamline class dynamics, I plan to designate specific timeframes for activities, ensuring a balanced and focused environment while actively intervening if discussions become overly verbose. Clear time markers will be established to maintain the lecture's planned progression, allowing for adaptability without compromising content quality. If feasible, content adjustments will be made to align with allotted time constraints, ensuring a more dynamic and engaging classroom setting.

In terms of student interactions, fostering open discussions in a conversational manner will be prioritized. Active engagement, especially addressing language barriers, will be a focal point, creating a more inclusive and participatory environment. Furthermore, I will work on projecting my voice effectively to enhance clar- ity during lectures. Learning from past experiences, I aim to optimize slide presentations by avoiding text overcrowding, and opting for a more visually digestible format that enhances comprehension.

Looking ahead, I aspire to integrate research-based education approaches into my teaching methodology. This connection between teaching and research not only facilitates networking and debate among students but also aligns with contemporary pedagogical trends (Dohn & Dolin, 2015).

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