

ELEPHANTS IN THE AMPHITHEATER

Nikola Luburić¹, Luka Dorić², Jelena Slivka³

^{1,2,3}University of Novi Sad, Faculty of Technical Sciences, Novi Sad, Serbia

¹nikola.luburic@uns.ac.rs, ²luka.doric@uns.ac.rs, ³slivkaje@uns.ac.rs

Abstract: Traditional education was not designed to prepare students for knowledge work. However, its learning technologies still permeate many aspects of public education, including higher education, leading to poor learning outcomes. A significant offender is the “knowledge-transfer lecture”, which is still prevalent in many universities, including in Serbia. With reliable access to digital technologies and the advancement of AI, there are more effective technologies for knowledge transfer. In a rapidly changing world, we need to rethink the goals of education, establish frameworks grounded in learning theory, and use them to produce learning technologies that achieve our goals. This paper composes a simple conceptual framework and uses it to redesign the traditional lecture. The resulting learning technology is empirically evaluated in a fourth-year undergraduate course and shows how time spent with an instructor in an amphitheater can produce significantly greater learning outcomes than mere knowledge transfer.

Key Words: competencies, learning technologies, learning principles, higher education, flipped classroom

1. INTRODUCTION

Mass schooling, formed during Victorian era industrialization, was designed to answer to the question: “How can we prepare children for factory work?” and not: “What environment would be best for children’s learning?” [1]. These designs, while useful for building discipline and social control, are less relevant for a civilization reliant on creativity and knowledge work. With the massification of higher education, universities adopted industrial-era technologies like mass lectures and standardized assessments to deal with larger and more diverse student populations.

Traditional lectures have dozens or hundreds of students observe an instructor that delivers knowledge. The main advantage of such lectures is efficient information delivery, where new information is simultaneously presented to many people. This advantage becomes moot when students have access to digital technologies and reliable energy, as video lectures result in similar knowledge retention given equal time [2] and give greater control to the student over the learning process (e.g., pause, reply, and play in your time). A secondary advantage of a lecture is the students’ access to an expert, but such access is not constrained to the traditional lecture.

Perhaps unsurprisingly, traditional lectures result in low knowledge retention [1][3]. Even when students are actively engaged, there seems to be little difference in knowledge retention, although motivation for learning does increase [3]. Finally, instructor presentation fluency, including proper use of voice dynamics, pauses, and non-verbal cues, does not influence knowledge retention [4]. The data suggests that knowledge transfer through an in-person lecture, regardless of instructor skill or technology use, is ineffective [3][4][5].

We can better understand these issues by exploring phenomena at our universities that harm lecture effectiveness:

- The schedule, which includes lectures early in the morning or late in the day, and a sequence of multiple lectures, chaining five to seven hours of passive learning.
- Student heterogeneity, where knowledgeable students find the lecture pace too slow, while students with poor prior knowledge cannot maintain pace with the instructor.
- Limited attention spans, where students get defocused, try to fill in the blanks, and lose track of the lecture as the instructor moves on.
- Instructor fatigue, where disseminating knowledge in a large amphitheater drains the instructor’s energy, leading them to be less clear and concise as the lecture nears its end.

Given these issues, it is common for students to disengage, waste time, and eventually stop attending nonmandatory lectures. Students that benefit the most are those that are ready to learn at the scheduled time, have enough knowledge to understand the lecture, but not significantly more to be bored by it, and have sufficient attention spans to keep pace with the instructor. However, such combinations of traits are rare in massive study programs.

Additionally, modern learning paradigms are less interested in knowledge retention and are focused on developing broader student competencies. The OECD Learning Compass 2030 defines competencies as knowledge, skills, attitudes, and values that students need to develop to contribute to the well-being of society [6]. In computer science, ACM and IEEE Computer Society align with this paradigm in their Computing Curricula report [7], which defines competencies as knowledge, skills, and dispositions that students employ to solve tasks. A traditional lecture focused on knowledge transfer is not sufficient to develop such competencies.

Despite the shortcomings of a traditional lecture, time spent with an instructor in an amphitheater can be a valuable learning experience, provided it is carefully assembled with the rest of the course activities and aligned with learning principles. In this paper, we introduce a simple framework for organizing lectures, based on contemporary

learning paradigms, technologies, and principles. We use the framework to analyze the traditional lecture, highlight its shortcomings, and propose alternatives.

In Section 2, we introduce the building blocks of our framework, including its learning paradigm, technologies, and principles. Section 3 presents our analysis of the traditional lecture using the framework. Section 4 discusses viable alternatives that transform the traditional lecture into a valuable learning experience. Section 5 presents our experiences from reorchestrating a set of lectures and includes anecdotal evidence that suggests the transformation produced meaningful learning experiences. Section 6 concludes the paper with a discussion of educational technologies that go beyond the amphitheater.

2. LEARNING PARADIGMS, TECHNOLOGIES, AND PRINCIPLES

The OECD Learning Compass [6] is a learning paradigm that aids educational systems in preparing students for a rapidly changing world. A key concept defined by this paradigm are *competencies*¹, which consist of:

- *Knowledge*, including facts, theories, and principles that are traditionally associated with education,
- *Skills*, including rules, heuristics, and problem-solving approaches students employ to complete tasks,
- *Attitudes*, including perspectives and feelings that affect our disposition and behavior towards certain ideas, objects, people, situations,
- *Values*, which are deeply held beliefs about what is important or desirable.

Knowledge has traditionally been the focus of education. However, technological development reduces the need for humans to remember knowledge, as it becomes embedded in checklists, chatbots, and artificial intelligence [1]. Skills required to solve tasks are also somewhat unstable as automation reduces the need for humans to solve tasks. There are two broad classes of skills worth considering – *domain-specific skills*, tied to a domain (e.g., software engineering), and *domain-general skills* that are not tied to a particular domain (e.g., digital literacy, critical thinking, teamwork) [8]. Domain-general skills are broadly applicable and less prone to deprecation than domain-specific skills. Notably, they are developed with domain-specific skills, while solving concrete learning tasks [8].

Instructors employ *learning technologies* to develop competencies in their students. Dron [9] defines a learning technology as an orchestration of digital and physical tools, models, methods, and phenomena to achieve learning objectives. Multiple technologies are *assembled* into a broader technology. For example, a PowerPoint presentation is a technology, as is an amphitheater. Both are assembled into a broader lecture, which is also a learning technology. Technologies are *soft* when they have little structure, and room for flexibility, diversity, and creativity by the instructor and students. They are *hard* when they are highly structured, leading to ease of use, efficiency, and reliability [9]. A multiple-choice question is a harder technology than an open-ended question. The softer the technology, the harder it is to reliably measure its impact on learning outcomes [9][10], since its results vary based on the instructor's *technique*. For example, an instructor with developed communication skills will engage more students in a group discussion than a junior instructor. On the other hand, a laboratory exercise that has students follow a procedure and requires no intervention from the instructor will generate consistent results regardless of the instructor's technique.

The final building blocks of our framework are *learning principles*, evidence-based truths about the learning process. A learning technology that adheres to learning principles produces better learning outcomes than when the same technology ignores these principles [9][10][11]. To illustrate, one learning principle states that new knowledge can only be developed on top of prior knowledge [11]. Instructors must ensure they understand their students' current competencies to develop and deploy a learning task aligned with this principle. Such a task places the student in the zone of proximal development, making it achievable and challenging, facilitating competency development [11]. Notably, learning principles are not related to any learning technology and can be embedded in any technology.

Ambrose et al. [11] define a prominent set of evidenced-based principles that promote learning. These include:

1. Students' prior knowledge can help or hinder learning. Instructors should understand if the students possess the knowledge, if it is active when needed, appropriate for the context, and not misconceived.
2. How students organize knowledge influences how they learn and apply what they know. Instructors should analyze the mental schemas resulting from learning, as not all schemas are suitable for all tasks.
3. Students' motivation generates, directs, and sustains what they do to learn. Instructors should establish learning value, build positive expectancies, and create a supportive learning environment.
4. To develop mastery, students must acquire component skills, practice integrating them, and know when to apply what they have learned. Instructors should define the structure of competencies they wish students to develop and provide learning opportunities for underdeveloped parts of the structure.
5. Goal-directed practice coupled with targeted feedback are critical to learning. Instructors should define performance objectives for the competency structure to evaluate student performance, provide targeted feedback and direct further practice.
6. Students' current level of development interacts with the social, emotional, and intellectual climate of the course to impact learning. Instructors should see their students as whole people going through an important period of their lives and adapt their tone and instruction accordingly.

¹ We use *italic* in this section to highlight key concepts of our conceptual framework, presented in Fig. 1.

7. To become self-directed learners, students must learn to assess the demands of the task, evaluate their competencies, plan an approach, monitor their progress, and adjust strategies as needed. Instructors should integrate opportunities for metacognition and domain-general skill development in their tasks.

We summarize the concepts introduced in this section in Fig. 1.

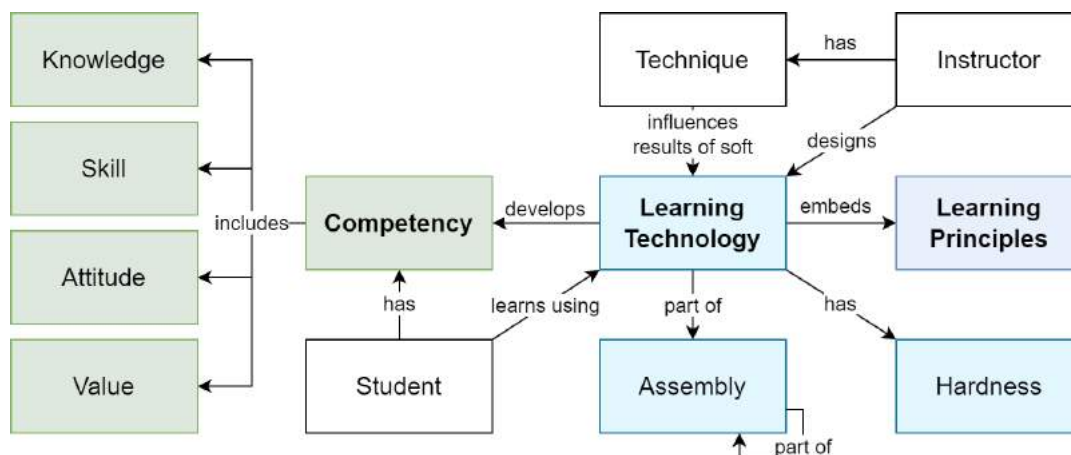


Figure 1 Conceptual framework that relates competencies, learning technologies and learning principles

3. ELEPHANT ANALYSIS

Given the previous framework, we analyze the traditional lecture that focuses on knowledge transfer.

The lecture is a learning technology that belongs to a broader technological assembly bounded by the course. This assembly might include laboratory exercises and their constituent learning technologies (e.g., lab equipment, learning tasks), the semester project and its constituent learning technologies (e.g., project specification, useful resources), and periodic summative assessments (e.g., colloquiums with varied questions). The learning objectives of the course assembly serve to identify the competencies that students should develop by the end of the course. Instructors then create subobjectives for constituent learning technologies (e.g., individual lectures and learning tasks).

The objective of a traditional lecture is to transfer knowledge to the students [5]. If successful, students can reproduce the knowledge and use it in other parts of the course assembly (e.g., to solve a learning task requiring this knowledge). The traditional lecture is an assembly of learning technologies that consists of, at minimum, the lecture hall (e.g., amphitheater), the tools the instructor is using to deliver information (e.g., blackboard, projector, slides), and the instructional method the instructor is employing while delivering information. Additional technologies might include the students' notebooks and their note-taking methods. Lectures incorporating active learning might include clicker questions, group discussions, or other formative assessment tasks between information delivery.

Each of the listed technologies can contribute to or detract from the lecture's objective. To illustrate, we consider a 15-minute period of a lecture, where the objective is to make students aware of concept A and teach them how to apply it when solving task B. This objective can be achieved using multiple approaches, including:

1. Presenting concept A and using it to solve task B, where the students passively observe this story,
2. Presenting concept A, presenting task B, and asking students to work in small groups to solve task B,
3. Presenting task B, asking students to work in small groups to solve task B, and presenting concept A.

The first approach can achieve the objective when most students have sufficient prior knowledge to understand concept A and its application and enough focus to follow the story. Provided the students engage with the group work, the second approach is more engaging and enables students to fill in gaps in prior knowledge when they are working with knowledgeable colleagues. The third approach works if the students can make sufficient progress on task B using their prior knowledge, where the goal is to identify the missing knowledge (concept A) and solve everything else. Which approach is suitable depends on the broader context of the lecture.

Notably, none of these approaches are valid if only a minority of students are engaged or possess the needed prior knowledge. In other words, these approaches fail if they are not aligned with learning principles concerning prior knowledge and motivation [11]. Furthermore, these approaches can be achieved using different and less expensive technologies. A video, text, or similar learning resource can replace a live presentation and an online chatroom or coffee table can replace an amphitheater for small group work. Such changes enable flexibility and reuse of the technology, which contributes more to the knowledge transfer learning objective than a scheduled presentation [1].

However, these changes require greater learner self-direction, making them viable for experienced students, but overwhelming for novices [8]. Novices require guidance for engaging with learning resources and deadlines that ensure they study these resources to prepare for the next steps of the course. Such support helps students deal with the flexibility and grows their self-regulated learning skills, an important objective to face future challenges [6].

The traditional lecture is a deprecated technology for achieving the goal of knowledge transfer. There are

technological assemblies that are less expensive to run, less reliant on instructor technique, and more effective in achieving knowledge transfer. However, this does not mean that we cannot design a valuable assembly that orchestrates an amphitheater, instructor, a group of students, and other technologies.

4. REORCHESTRATING THE LECTURE

Learning resources are an effective way to present knowledge [1], while *learning tasks* that students complete present a good way to develop skills that use that knowledge [8]. While values and attitudes can and should be embedded into learning resources and tasks, these concepts are closely related to what it means to be human and can be better understood by directly interacting with a human [6]. Furthermore, students are more likely to enhance their attitudes and values, engage with the course, and avoid cheating when instructors build a *connection* and show they care [11][12]. Fig. 2 showcases how the listed concepts collectively develop all dimensions of the OECD competency.

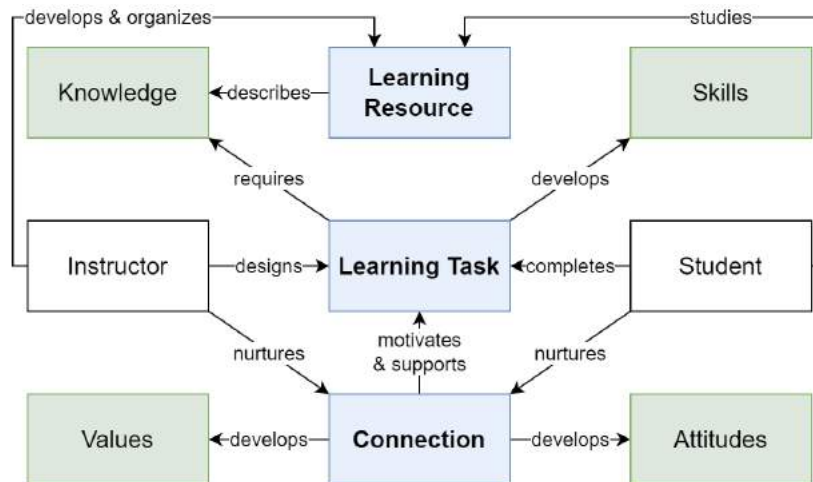


Figure 2 Three pillars of student competency development

When considering this evidence and other learning principles, we conclude that time spent with an instructor in an amphitheater is meaningful when it deepens the connection between the involved parties. This connection can be leveraged during the lecture period to serve three objectives:

1. Developing healthy and productive attitudes and values,
2. Understanding student misconceptions and challenges and offering corrective feedback for knowledge and skill development,
3. Understanding student needs and course deficiencies and defining corrective measures to continuously improve the course.

A well-known technology for supporting these objectives is the flipped classroom, where students examine learning resources before the lecture and come prepared with questions for the instructor [13]. A reorchestrated lecture based on the flipped classroom, which contributes to the three objectives, might be designed as follows:

0. Students go over the learning resources and write down any questions and uncertainties,
1. The instructor asks students to share how they are progressing with their work, gives domain-general feedback (e.g., self-regulation, self-organization), and answers domain-specific questions,
2. The instructor administers learning tasks that require group work and discussion to solve, reinforcing the developed knowledge and domain-specific skills, removing misconceptions, and enhancing domain-general skills (e.g., collaboration, communication).
3. The instructor shares one or more authentic stories that showcase some of the topics from the learning resources, highlighting any attitudes and values embedded in the story (e.g., the moral of the story).

We examine how such a technology can adhere to the principles defined by Ambrose et al. [11]:

1. Provided that students study the learning resources (step 0), they come with the necessary prior knowledge to benefit from the lecture, aligning with the first principle.
2. The knowledge in the learning resources (step 0) should be organized according to the needs of the lecture tasks and other tasks in the course assembly, adhering to the second principle.
3. The lecture presents a good opportunity to support the third principle, where the instructor highlights the course's value (step 3) and supports students (steps 1 and 2).
4. The fourth principle applies to the tasks, where instructors design progressively more challenging tasks (step 2) that give students opportunities to develop constituent skills.
5. The fifth principle is supported by establishing clear goals (i.e., task completion) and offering feedback based on the results (step 2).

6. By connecting with students (step 1), the instructor better understands their needs, social, emotional, and intellectual development and can adjust the course's tone, adhering to the sixth principle.
7. By eliciting feedback from students regarding their challenges and needs (step 1), the instructor can provide useful domain-general advice that develops students' metacognition.

It is worth pointing out that some of the listed properties can be embedded into traditional lectures. However, flipped classrooms free up much of the instructor's time, enabling them to progress slowly, connect, and bring greater value to the students than mere knowledge presentation. Furthermore, the proposed reorchestration of the lecture is not the only option for fulfilling the three objectives defined above. Finally, each lecture is part of a larger technological assembly, which includes not only other course activities but other lectures. Consequently, not every lecture needs to follow the same format nor target all three objectives.

5. ANECDOTES FROM REORCHESTRATED LECTURES

Apart from researching learning technologies, the authors of this paper have experimented with alternative classroom orchestrations in the many lectures and laboratory exercises they conducted. Here we summarize a recent lecture design of the 2023/2024 iteration of a fourth-year undergraduate course focused on *software design*. We then describe several anecdotes that indicate that the reorchestrated lectures contribute to significant learning experiences.

The course *software design* is anchored in project-based learning [14], where the project involves creating a large software system in a team of 16 students. Students complete a sequence of progressively more challenging learning tasks that expand the joint software solution. All materials that would traditionally be presented during a lecture were digitalized as text or video and organized to help students complete the project's tasks. Each lecture started with a discussion of the semester's challenges and ended with a Q&A session focused on the project. There were three activity types that filled the middle:

1. Review of the upcoming project tasks, where the instructor presented novel challenges for the coming weeks and designed solutions with the students,
2. Analysis of real-life case studies that were relevant to the developed knowledge and skills, where the instructor integrated stories aimed at developing attitudes and values,
3. A 45-minute discussion with individual teams, focused on understanding team dynamics and challenges, proposing solutions, improving the students' collaborative domain-general skills, and deepening the connection between all involved.

All activities, along with the Q&A sessions, served to clarify misconceptions and give corrective feedback. The introductory discussion and the second and third activities influenced attitudes and values. Finally, the introductory discussion, Q&A sessions, and the third activity increased understanding of students' needs and course deficiencies.

We observed multiple interesting phenomena in our students, where we highlight several of the most significant:

- Despite not being a requirement, five out of eight teams organized team-building activities and cheerfully presented photos from the event (two teams had multiple team-building activities).
- During the first team discussion with the instructor, a student identified that she had significant trouble asking for help and the group brainstormed solutions. For the next team discussion, she stood tall as she proudly proclaimed that she had managed to deal with this issue.
- During a team discussion with the instructor, two members of the team pointed out that they got into a significant conflict that ended their personal relationship. After the group discussion, the instructor spoke with the person instigating the conflict, which resulted in a paradigm shift for the student as he took responsibility for the conflict and concluded that he needed to work on his active listening skills.
- Near the end of the semester, three students wrote one to two A4 pages of thoughts regarding their development, deficiencies, and prospects. They sent these thoughts to the instructor to get feedback on how to improve and progress with their learning once the course was over.
- 60 of the 120 students attended the last lecture during the peak of their exam month. The lecture summarized the competency growth that happened during the course, projected it into the future, and stressed the value of lifelong learning. It ended with an ovation.
- The instructor memorized the names of roughly 40 of the 120 students and was invited to a team-building activity after the course.

It is worth pointing out that these results do not stem from the charisma or technique of the instructor, as almost no similar anecdotes were observed in courses with traditional lectures that were conducted by the same instructor. Next, the results do not stem from the lack of challenge, as most students consider the software design course to be the most challenging in the semester. Finally, the results do not stem from the new lecture format alone. Rather, these anecdotes result from the careful orchestration of the whole course and its constituent technological assemblies.

6. CONCLUSION

Many university instructors are also scientists. As scientists, we rigorously research a domain to identify and thoroughly understand its core concepts and first principles. As instructors, we often avoid this process and reuse the

formula that has been handed down to us from previous generations. Our conceptual models for higher education revolve around lectures, exercises, and tests, and often stress knowledge acquisition as the sole objective. As we have discussed in Section 2, there are better primitives we can use to analyze our courses and design improved learning experiences. The first step involves choosing a learning paradigm that sets a framework for defining learning objectives. The second step requires designing assemblies of learning technologies that are aligned with learning principles and that fulfill subobjectives that contribute to the broader goals.

In this paper we have examined the traditional lecture as a common learning technology using these primitives to highlight its deficiencies. We then presented a reorchestrated lecture that employs similar resources in a different way to achieve meaningful learning outcomes. Finally, we presented anecdotal evidence to highlight meaningful phenomena we observed with the alternative lecture format.

The concepts summarized in Fig. 1 and Fig. 2 go beyond the lecture. They are broad building blocks that can frame any learning experience, including formal education, vocational training programs, and hackathons. While these concepts do not present the only valid view of education, they reveal a greater truth about learning than the primitives we are used to using when we disengage from our job as university instructors.

7. LITERATURE

- [1] Shackleton-Jones, N., 2019. How people learn: Designing education and training that works to improve performance. Kogan Page Publishers.
- [2] Alharbi, H.A., Shehadeh, F. and Awaji, N.Y., 2022. Immediate knowledge retention among nursing students in live lecture and video-recorded lecture: A quasi-experimental study. *Nurse Education in Practice*, 60, p.103307.
- [3] Van Dijk, L., Van Der Berg, G.C. and Van Keulen, H., 2001. Interactive lectures in engineering education. *European Journal of Engineering Education*, 26(1), pp.15-28.
- [4] Toftness, A.R., Carpenter, S.K., Geller, J., Lauber, S., Johnson, M. and Armstrong, P.I., 2018. Instructor fluency leads to higher confidence in learning, but not better learning. *Metacognition and Learning*, 13, pp.1-14.
- [5] Stains, M., Harshman, J., Barker, M.K., Chasteen, S.V., Cole, R., DeChenne-Peters, S.E., Eagan Jr, M.K., Esson, J.M., Knight, J.K., Laski, F.A. and Levis-Fitzgerald, M., 2018. Anatomy of STEM teaching in North American universities. *Science*, 359(6383), pp.1468-1470.
- [6] OECD, 2019. OECD future of education and skills 2030: OECD learning compass 2030.
- [7] CC2020 Task Force, 2020. Computing Curricula 2020: Paradigms for Global Computing Education. Association for Computing Machinery, New York, NY, USA.
- [8] Van Merriënboer, J.J. and Kirschner, P.A., 2017. Ten steps to complex learning: A systematic approach to four-component instructional design. Routledge.
- [9] Dron, J., 2023. How education works: teaching, technology, and technique. Athabasca University Press.
- [10] Hattie, J., 2012. Visible learning for teachers: Maximizing impact on learning. Routledge.
- [11] Ambrose, S.A., Bridges, M.W., DiPietro, M., Lovett, M.C. and Norman, M.K., 2010. How learning works: Seven research-based principles for smart teaching. John Wiley & Sons.
- [12] Amerstorfer, C.M. and Freiin von Münster-Kistner, C., 2021. Student perceptions of academic engagement and student-teacher relationships in problem-based learning. *Frontiers in psychology*, 12, p.4978.
- [13] Akçayır, G. and Akçayır, M., 2018. The flipped classroom: A review of its advantages and challenges. *Computers & Education*, 126, pp.334-345.
- [14] Larmer, J., Mergendoller, J. and Boss, S., 2015. Setting the standard for project based learning. ASCD.