Lecture Notes in Networks and Systems 389

Michael E. Auer
Hanno Hortsch
Oliver Michler
Thomas Köhler *Editors*

Mobility for Smart Cities and Regional Development - Challenges for Higher Education

Proceedings of the 24th International Conference on Interactive Collaborative Learning (ICL2021), Volume 1

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Preface

ICL2021 was the 24th edition of the International Conference on Interactive Collaborative Learning and the 50th edition of the IGIP International Conference on Engineering Pedagogy.

This interdisciplinary conference aims to focus on the exchange of relevant trends and research results as well as the presentation of practical experiences in Interactive Collaborative Learning and Engineering Pedagogy.

ICL2021 has been organized by Technische Universität Dresden and University of Applied Science Dresden, Germany, from September 22 to 24, 2021, as a hybrid event.

This year's theme of the conference was "Mobility for Smart Cities and Regional Development – Challenges for Higher Education".

Again, outstanding scientists from around the world accepted the invitation for keynote speeches:

- **Gyeung Ho Choi**, Professor at Daegu Gyeongbuk Institute of Science and Technology, Korea.
  Speech title: Challenges for Future Mobility
- **Thoralf Knote**, Head of Department, Fraunhofer Institute IVI, Germany.
  Speech title: *Involvement of Students in the Project Work at Fraunhofer IVI*
- **Krishna Vedula**, Founder and Executive Director of IUCEE, India.
  Speech title: *Addressing the Challenges of Engineering Pedagogy in India*
- **Stefan Odenbach**, Dean of Studies for Mechanical Engineering at TU Dresden, Germany
  Speech title: *Practical Courses without Presence – is this possible?*
- **David Guralnick,** Kaleidoscope Learning, USA
  Speech title: *Successful Learning Experiences Design*
- **Lars Seiffert,** Board Member, Verkehrsbetriebe AG Dresden, Germany
  Speech title: *Priority for Public Transport – Fair and Green*
- **Ulrike Stopka,** Professor for Communications Economics and Management at TU Dresden, Germany

Speech title: *Challenges and Opportunities for a Transport Sciences-Oriented Study Program*

The following very interesting workshops have been held:

- ***Modern Vehicle Engineering Training up to Connected and Automated Driving***
  Facilitators: **Oliver Michler, Professor for Traffic Telematics at TU Dresden, Germany, and Toralf Trautmann, Professor for Mechatronics at University of Applied Sciences Dresden, Germany**
- ***From Face-to-Face to Hybrid Events – Experiences with the Digital Transformation of a Conference Series Dealing with Online Network Research***
  Facilitator: **Thomas Köhler**, **Professor for Media Technology at TU Dresden and Director of the Center for Open Digital Innovation and Participation at TU Dresden**

We would like to thank the organizers of the following Special Sessions:

- Games in Engineering Education (GinEE)
  Chair: **Matthias C. Utesch**, FOS/BOS Technik München, Germany
- Entrepreneurship in Engineering Education 2020" (EiEE'20)
  Chair: **Jürgen Jantschgi**, HTL Wolfsberg, Austria
- Engineering Education for "Smart Work" and "Smart Life" (IPW)
  Chair: **Steffen Kersten**, TU Dresden, Germany
- Assessing and Enhancing Student online Participation and Engagement
  Chair: **M. Samir Abou El-Seoud**, The British University in Egypt
- Smart Education of Digital Era
  Chair: **Irirna Victorovna Makarova**, Kazan Federal University, Russia

Since its beginning, this conference is devoted to new approaches in learning with a focus to collaborative learning and engineering education. We are currently witnessing a significant transformation in the development of education. There are at least three essential and challenging elements of this transformation process that have to be tackled in education:

- the impact of globalization and digitalization on all areas of human life,
- the exponential acceleration of the developments in technology as well as of the global markets and the necessity of flexibility and agility in education,
- the new generation of students, who are always online and don't know live without Internet.

Therefore, the following main themes have been discussed in detail:

- Collaborative Learning
- Mobility and Smart Cities
- New Learning Models and Applications
- Project-Based Learning

- Game-Based Education
- Educational Virtual Environments
- Computer-Aided Language Learning (CALL)
- Teaching Best Practices
- Engineering Pedagogy Education
- Public-Private Partnership and Entrepreneurship Education
- Research in Engineering Pedagogy
- Evaluation and Outcomes Assessment
- Internet of Things and Online Laboratories
- IT and Knowledge Management in Education
- Approaches of Online Teaching
- Virtual and Augmented Learning
- Mobile Learning Applications
- Connection between Universities and the Labor Market
- Further Education for Engineering Educators

As submission types have been accepted:

- Full Paper, Short Paper
- Work in Progress, Poster
- Special Sessions
- Workshops, Tutorials.

All contributions were subject to a double-blind review. The review process was very competitive. We had to review more than 500 submissions. A team of about 240 reviewers did this terrific job. Our special thanks go to all of them.

Due to the time and conference schedule restrictions, we could finally accept only the best 156 submissions for presentation.

The conference had more than 250 online and on-site participants from 42 countries from all continents.

Our special thank goes to **Prof. Dr. Thomas Köhler and his team** of Technische Universität Dresden, Germany, who made the hybrid conference a reality. We thank **Sebastian Schreiter** for the technical editing of this proceedings.

ICL2022 will be held in Vienna, Austria.

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New Learning Models and Applications

Collaborative Learning

Adapting Materials for Diverse Contexts to Help Faculty Adopt Process Oriented Guided Inquiry Learning (POGIL)

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Abstract. Process Oriented Guided Inquiry Learning (POGIL) is an approach to teaching and learning in which students work in teams to practice important professional skills and develop their own understanding of key concepts. Numerous studies have found that POGIL increase student motivation and learning. POGIL and related approaches can be a significant change for many instructors, so The POGIL Project has developed numerous workshops to help faculty understand POGIL principles and practices, and learn to create activities and facilitate student learning. However, these workshops were developed by and for STEM faculty in the US. In the last decade, POGIL workshops increasingly target other disciplines, cultures, and countries. This has highlighted limitations and opportunities to improve the workshops. This paper briefly describes POGIL, the author's experiences adapting POGIL workshops and materials for faculty in diverse contexts, and lessons learned that could help to adapt other materials.

Keywords: POGIL · Professional development · Universal design · Workshop

1 Introduction

Over the last 20 or more years, a variety of evidence-based approaches to teaching and learning have been developed, validated, and disseminated. This paper focuses on one such approach, *Process Oriented Guided Inquiry Learning (POGIL)*. To help faculty learn about and implement POGIL practices in their classes, the POGIL community regularly offers ½-day, 1-day, and multi-day workshops. However, the workshop sessions were developed by and for faculty in the United States. The author has led over 40 POGIL workshops in the US, over 20 in southern India [e.g., 1–4], as well as in Ghana, Switzerland, and Vietnam. This paper describes why and how workshops were adapted for such settings. The lessons learned should be relevant when adapting other learning materials to other contexts.

The rest of this paper is organized as follows. Section 2 briefly describes POGIL, a sample POGIL activity, and the POGIL workshops for faculty. Section 3 describes a set of recommendations based on the author's experiences adapting workshop materials for diverse contexts. Section 4 provides conclusions and future directions.

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2 Process Oriented Guided Inquiry Learning

The *ICAP model* (Interactive, Constructive, Active, Passive) [5] describes how learning outcomes improve as the learning environment progresses from *passive* to *active* to *constructive* (learners create their own understanding) to *interactive* (learners work together and explain concepts to each other). Learning that is both interactive and constructive is also called *social constructivism*.

In a POGIL class, teams of students (typically 3–5) work together to practice teamwork, critical thinking, and other important skills. The teams work on learning activities that guide them to interact and construct their own understanding of key concepts. The instructor observes and listens to students, provides encouragement and help, and leads class discussions about key ideas. Thus, POGIL is learner-centered, not teacher-centered [6, 7]. A POGIL activity consists of one or more *models* (e.g., tables, graphs, diagrams, computer code) each followed by a sequence of *critical thinking questions* that guide students through *explore-invent-apply learning cycles* to *explore* the model, *invent* their own understanding of a new concept, and then *apply* that understanding.

POGIL was initially developed for chemistry [e.g., 8] but has since spread to many other STEM disciplines [e.g., 9–12]. Numerous research studies have found that POGIL improves student motivation and learning, despite faculty concerns about "covering" enough content. (For a recent summary of research on POGIL, see [13]). For example, a survey of POGIL faculty in computer science found strong agreement that students are more engaged, more active, develop deeper understanding, and develop relevant skills [14]. The POGIL Project (http://pogil.org) is a non-profit organization that develops and provides training; reviews, endorses, and publishes POGIL activities; and provides other support for POGIL practitioners.

2.1 Sample POGIL Activity: Models of Disease

This section briefly describes the initial sections of a POGIL style activity designed for an introductory programming course. The activity guides student teams to explore a sequence of models for how diseases spread through a population. In doing so, students learn about modeling, program design, and iterative development practices. Students also gain experience in teamwork, critical thinking, and problem solving.

The activity starts with a brief introduction to motivate the activity, shown in Fig. 1. Too often, instructors introduce new concepts without context or motivation, but an appropriate example or sample problem can help to engage students.

Section A presents two *compartmental models*, shown in Fig. 2. The early questions prompt students to explore these models, by noting how many stages and transitions are in each model, and whether a person can become sick more than once. Later questions prompt students to invent their own understanding, and explain the common name for each model (SIS and SIR). These questions are not intended to be difficult, but to ensure that students understand the models and are better prepared to work with more complex models later in the activity.

Section B starts with a short block of pseudocode, shown in Fig. 3. Questions prompt students to explore the pseudocode to identify the key phases and sub-phases,

Diseases that are infectious and spread easily can have large, deadly impacts. In the 1300s, the **Black Death** killed 75-200 million people (30-60% of the population) in Europe, Asia, and North Africa. The **Cocoliztli Epidemic** of 1545-48 killed 5-15 million people (80% of the population) in what is now Mexico. In 1918-20, the **Spanish flu** killed 75 million people worldwide, nearly four times as many as World War I. More recently, **HIV/AIDS** has killed over 30 million people since 1960.
This activity explores ways to model and simulate the spread of a disease.
The same concepts and techniques are used in other types of modeling.

Fig. 1. Introduction to activity on disease models

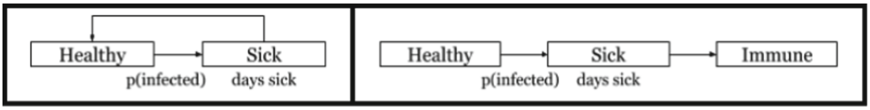

Fig. 2. Compartmental models for section A of activity on disease models.

and understand how the simulation works. Students are then asked to choose which phases will be easiest and hardest, and to explain their reasoning; this would be obvious to an instructor or experienced developer, but is often not obvious to novices. Next, students are given several pages of starter code (in Python), and questions prompt students to look through the code to see how many functions are defined, which will need to be completed, which are tests, etc.

```
make population (one individual at a time)
    make individual
run simulation (one day at a time)
    update population (one individual at a time)
        update individual
    check for new infections
    summarize results (for day)
summarize results (for simulation) (e.g., graph, table)
```

Fig. 3. Pseudocode for section B of activity on Disease Models.

Section C starts with a short block of Python code that defines a set of variables, shown in Fig. 4. Questions prompt students to explore the variables, identify elements, and connect them back to the compartmental models, pseudocode, and starter code. Later questions prompt students to create new sets of variables to represent other diseases and conditions.

```
# individuals and population
indA    =   { "stage":"healthy", "days":0 }
indB    =   { "stage":"sick",    "days":5 }
pop     = [ { "stage":"healthy", "days":0 },
            { "stage":"sick",    "days":2 },
            { "stage":"healthy", "days":0 } ]
# daily summary and history
day1    =   { "healthy":1, "sick":1 }
hist    = [ { "healthy":1, "sick":1 },
            { "healthy":1, "sick":1 },
            { "healthy":2, "sick":0 } ]
```

Fig. 4. Simulation data values for section C of activity on disease models.

Thus, in the course of this classroom activity, students explore and invent understanding of graphical models, pseudocode, starter code, data representations, and good development practices, and how these different elements are interrelated. To some instructors, this approach seems time-consuming and inefficient, but an activity like this can help students to develop deeper understanding so that they are more confident and successful with the programming assignment, and with future assignments.

2.2 Faculty Professional Development

Unfortunately, not enough instructors adopt evidence-based approaches [15], despite varied propagation efforts [e.g., 16, 17]. To help instructors learn about POGIL principles and practices, The POGIL Project has developed a set of professional development workshop sessions for instructors, trains experienced POGIL instructors to lead these sessions, and offers ½-day, 1-day, and multi-day workshops at professional conferences and academic institutions. Table 1 lists sessions in a typical 3-day workshop. To a large extent, the sessions use POGIL practices to help instructors learn about POGIL; for example, instructors work through a short POGIL activity (as students), and then work through a second meta-activity to reflect on what they did, what the instructor did, and how the activity's structure supported their learning.

Table 1. Workshop Sessions developed by The POGIL Project

Introductory	*Activity Authoring*
• Fundamentals of POGIL	• Activity Structure
Classroom Facilitation	• Learning Objectives & Scaffolding
• Team Formation	• Robust Models
• Modeling a POGIL Classroom	• Activity Rubrics for Feedback
• Improving Facilitation Skills	• Author Coaching
• Scenarios & Effective Strategies	*Other*
• Introducing Process Skills	• POGIL Laboratories (6 sessions)
• Using & Assessing Process Skills	• Inclusive Excellence
• Facilitator Toolbox	• Scholarship of Teaching & Learning

3 Adapting Materials in Diverse Contexts

The workshop sessions described above were mostly developed by and used with college and high school instructors who teach STEM (science, technology, engineering, and mathematics) in the US. The POGIL Project solicits feedback from workshop participants and leaders, which is used to identify and fix problems, and consider ways to continually improve the workshops.

However, the workshop sessions are increasingly used in more diverse contexts. For example, the author has led workshops in India, Ghana, Switzerland, and Vietnam, and other POGIL practitioners have led workshops in China, Japan, South Africa, and South Korea. These workshops present a variety of challenges. For example:

- Participants might have different levels of English language proficiency, especially when materials and conversations involve abstract concepts in education and other academic disciplines.
- Some activities and examples assume that participants are familiar with US customs, geography, currency, and society, and thus might be confusing in other contexts. For example, in India, 100,000 is written 1,00,000 (one lakh) and 10,000,000 (ten million) is written 1,00,00,000 (one crore). The author has led workshops with over 50 participants, none of whom could describe or draw a "Star of David".
- In the US, The POGIL Project typically gives every participant printed copies of the handouts, notes, and other materials for a workshop. Outside the US, sending materials might be too expensive, or they might never arrive (as happened to the author in Ghana). Preparing materials locally can be complicated and can result in errors.

Based on experiences adapting workshop sessions for other contexts, we offer a set of recommendations, divided into several broad categories. The term "learners" refers to participants in a workshop, but also applies to students in a course. Thus, these recommendations are also relevant to adapting classroom materials.

Note that many of these recommendations are examples of *universal design* [18, 19]; efforts to remove barriers and expand access for specific populations often have similar benefits for broader populations.

3.1 Strategic Recommendations

These higher-level recommendations should guide everything else.

Focus on How to Help Learners Interact and Construct Understanding. As outlined above, the ICAP Model [5] describes how learning outcomes improve as contexts become more *active*, *constructive*, and *interactive*. Similarly, POGIL provides a framework to make this happen. There is always pressure to "cover" as much content as possible, but it is more important to focus on the impact on the learner. An instructor who "covers" content that learners don't understand or remember is wasting time; learners who truly understand key concepts and master skills are empowered to learn more on their own. For example:

- Meet with some learners before the workshop, or observe some class sessions, to better understand the range of common practices.
- Although workshop sessions might have minute-by-minute schedules, be ready to adjust based on learner behavior and needs, to allow more time for key topics, and omit topics as necessary, rather than pushing too hard to follow a schedule that doesn't work for the learners.

Use Tight Feedback Loops to Quickly Identify and Respond to Problems. Tom Peters, the business writer and speaker, is quoted as saying "Test fast, fail fast, adjust fast" – the sooner we try something and find out whether it works or not, the sooner we can do something about it. A sequence of small successes is better than a large effort that fails. An instructor who lectures without any student feedback doesn't know what they are learning and when they are confused. For example:

- Split long sessions into shorter pieces that alternate with quick feedback activities.
- Check the learners' answers and confidence frequently – every few minutes, ideally. Phone apps and clicker devices can help, but colored cards or a show of hands can be quite effective too.
- Use "think-pair-share" questions, where learners think about their own answer, then chat with a partner, and then a few pairs share their answers with the whole group.

Encourage Small Steps to Build Confidence. New approaches to teaching and learning can intimidate students and instructors. Find ways to help people see benefits, even small ones, as quickly as possible. Follow new ideas or techniques with short opportunities to apply them. For example:

- Decompose complex ideas into simpler ideas and check that learners understand each part. POGIL activities use learning cycles (described above); the author often finds that more, shorter cycles increase student confidence and persistence.
- POGIL is a set of practices that work well together, but also work well individually, so the author explicitly lists the practices and suggests a few to try first. Instructors who have good experiences with a few practices are likely to try more, while instructors who take on too much and have problems might give up in frustration.
- Writing a POGIL style activity can be slow and difficult, so the author developed a workshop session to help instructors quickly write a mini-activity they could pilot in their own classes.

Allow More Time in Unfamiliar Settings. Sessions and activities that work well in one context will likely work less well and take more time in other contexts. Differences in culture and language can introduce misunderstandings and confusion that take time to resolve. For example:

- Schedule 120 min for a session that would normally take 90 min, and run at most three sessions a day, not four or five.
- Consider options if the workshop starts late due to travel delays, technical issues, or unexpected changes. On multiple occasions, the author has arrived late for work-shop, had to meet first with an academic leader, reached the workshop location after

participants were assembled, participated in an opening ceremony, and then had to connect to a projector and organize printed materials, before starting the first session, nearly an hour later than scheduled.

3.2 Tactical Recommendations for Materials and Presentation

These lower-level recommendations focus on materials, including slides, handouts, and worksheets, and how they are organized and presented. When the instructor and/or materials use a language that is not a preferred language for some or all learners, those learners face additional challenges and need extra support. For example, learners in Europe and India are usually proficient in English but are often more proficient in a language native to their own state or country.

Simplify Language, Structures, and Examples. Blaise Pascal, Benjamin Franklin, Mark Twain, and others have been quoted as apologizing for a long letter because they didn't have time to make it shorter. A first draft often seeks to capture an idea, not to express it clearly; later drafts (and mature workshop sessions) should seek to simplify and clarify. For example:

- Use active voice, not passive voice; e.g., "solve problems" instead of "problems should be solved".
- Use verbs, not related nouns; e.g., "explore" instead of "exploring" (a gerund) or "exploration" (a nominalization).
- Use parallel structures to emphasize similarities and reduce the amount of effort needed for a set of related ideas.
- Find a website or program that computes readability scores [e.g., 20, 21] and revise the text to improve the score. This often results in shorter sentences and fewer long or unfamiliar words.
- If possible, translate some materials into a language more familiar to learners, enlist assistants who can converse in their language(s), or provide materials in advance so learners can skim and lookup unfamiliar words. (This can also help learners with vision or reading impairments.)

The author rewrote an overview of POGIL. The original text was:

POGIL is an acronym for Process Oriented Guided Inquiry Learning. It is a student-centered instructional approach that simultaneously develops discipline content mastery and key process skills such as critical thinking, self-assessment and teamwork — skills that are valuable in the workforce.

A POGIL classroom consists of students working in small self-managed teams on specially designed guided inquiry materials. These materials supply students with data or information to interpret followed by guiding questions designed to lead them toward concept development – essentially a recapitulation of the scientific process. The instructor serves as facilitator, observing and addressing individual and classroom-wide needs.