What is SLAM?

Estimate the robot's path and the map

$$p(x_{0:T}, m \mid z_{1:T}, u_{1:T})$$

distribution path map given observations controls
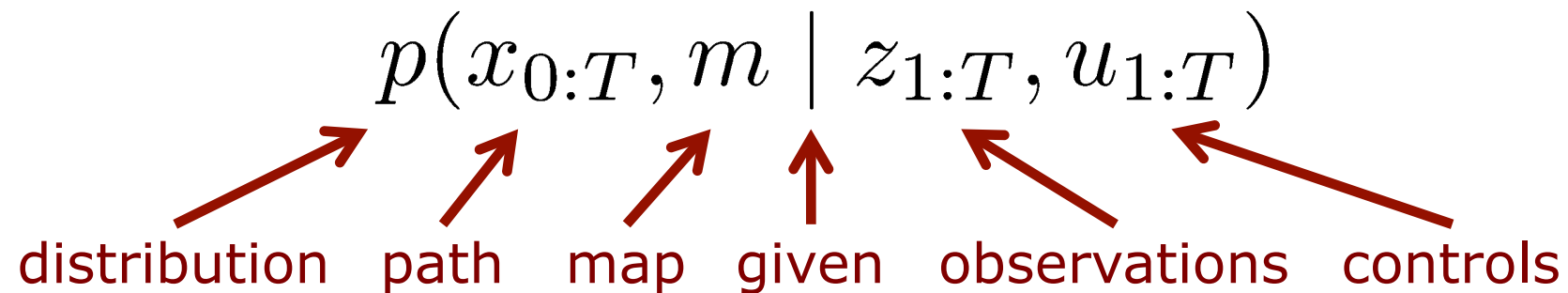
The SLAM Problem

- SLAM is a **chicken-or-egg** problem:
  - → a map is needed for localization and
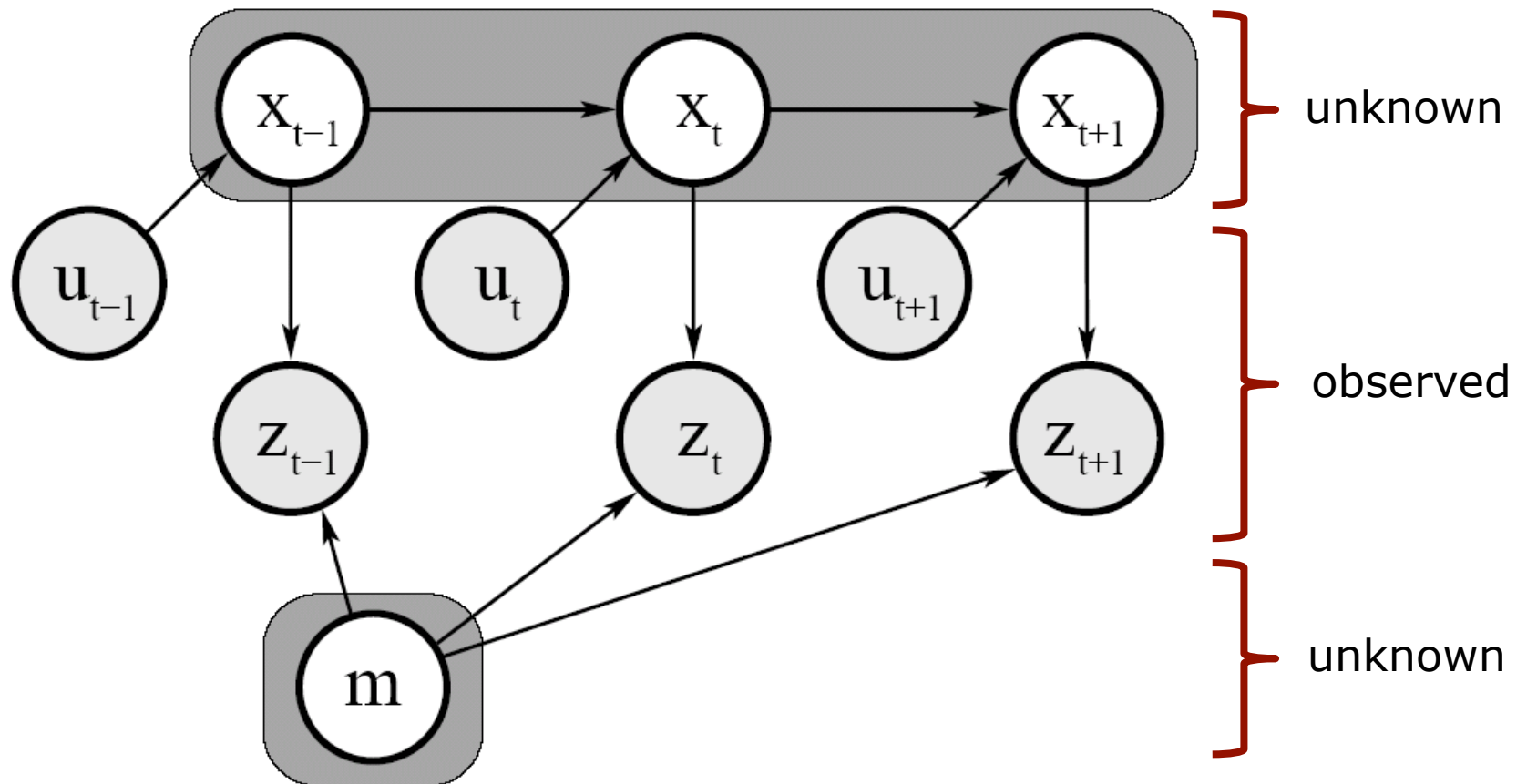 - → a pose estimate is needed for mapping

Three Main Paradigms

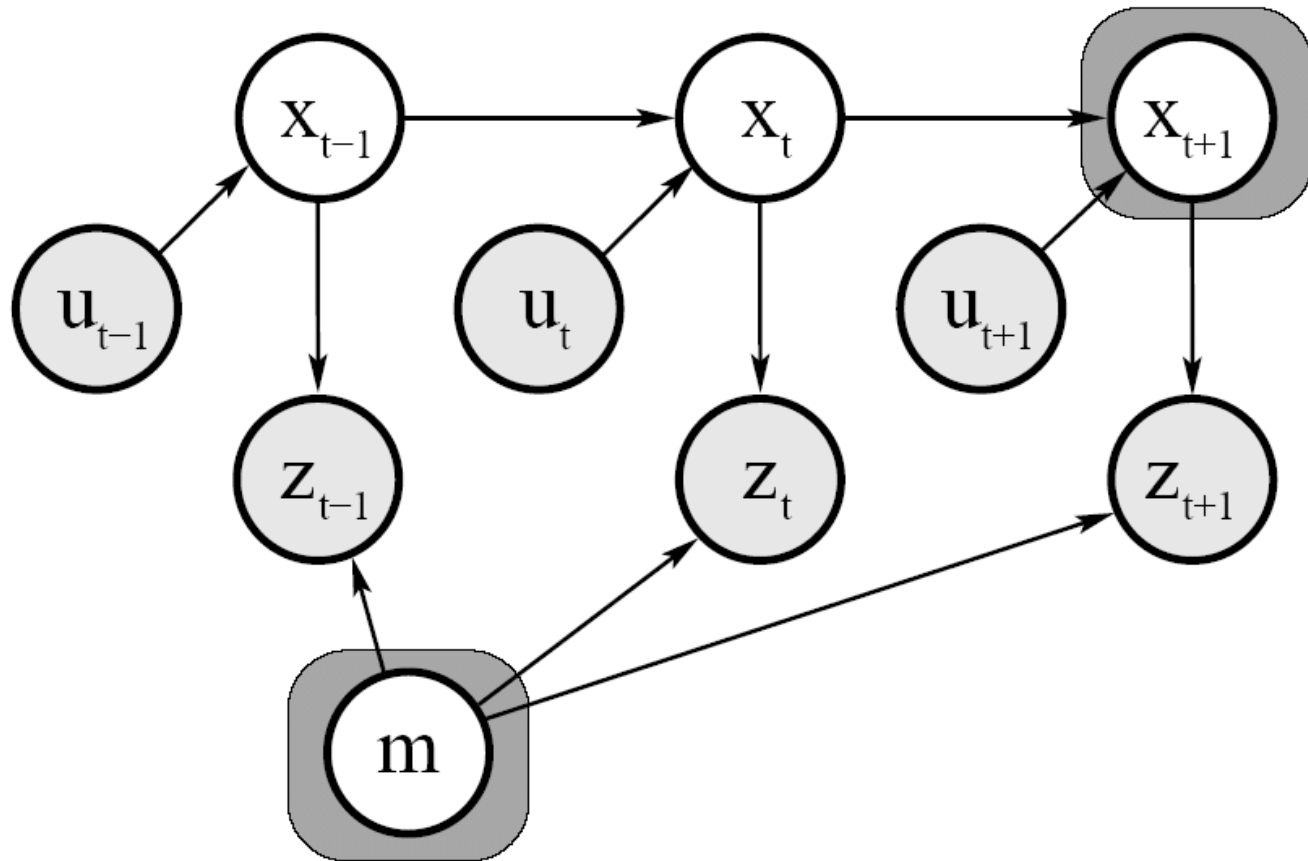| Kalman filter	Particle filter	Graph-based

Graphical Model of Full SLAM

$$p(x_{0:T}, m \mid z_{1:T}, u_{1:T})$$

Graphical Model of Online SLAM

$$p(x_{t+1}, m \mid z_{1:t+1}, u_{1:t+1})$$

What You Should Have Learned

- SLAM problem
- Build landmark and grid maps
- EKF SLAM
- SEIF SLAM
- Particle filter-based SLAM
- Graph-based SLAM
- Front-Ends
- Hands-on experience (programing)
- Understand average SLAM papers

Comparison of Approaches

- KF
- EKF
- UKF
- EIF
- SEIF
- FastSLAM
- Grid-FastSLAM
- Graph-Based SGD/TORO
- Graph-Based GN & LM

# **Where Do You See Open Issues?**

Open Issues in SLAM

- Dynamic environments
- Systematically changing environments
- Seasonal changes
- Online solutions
- Life-long operation
- Resource-constraint systems
- Failure recovery/zero user intervention
- Exploiting prior knowledge
- Robots sharing maps
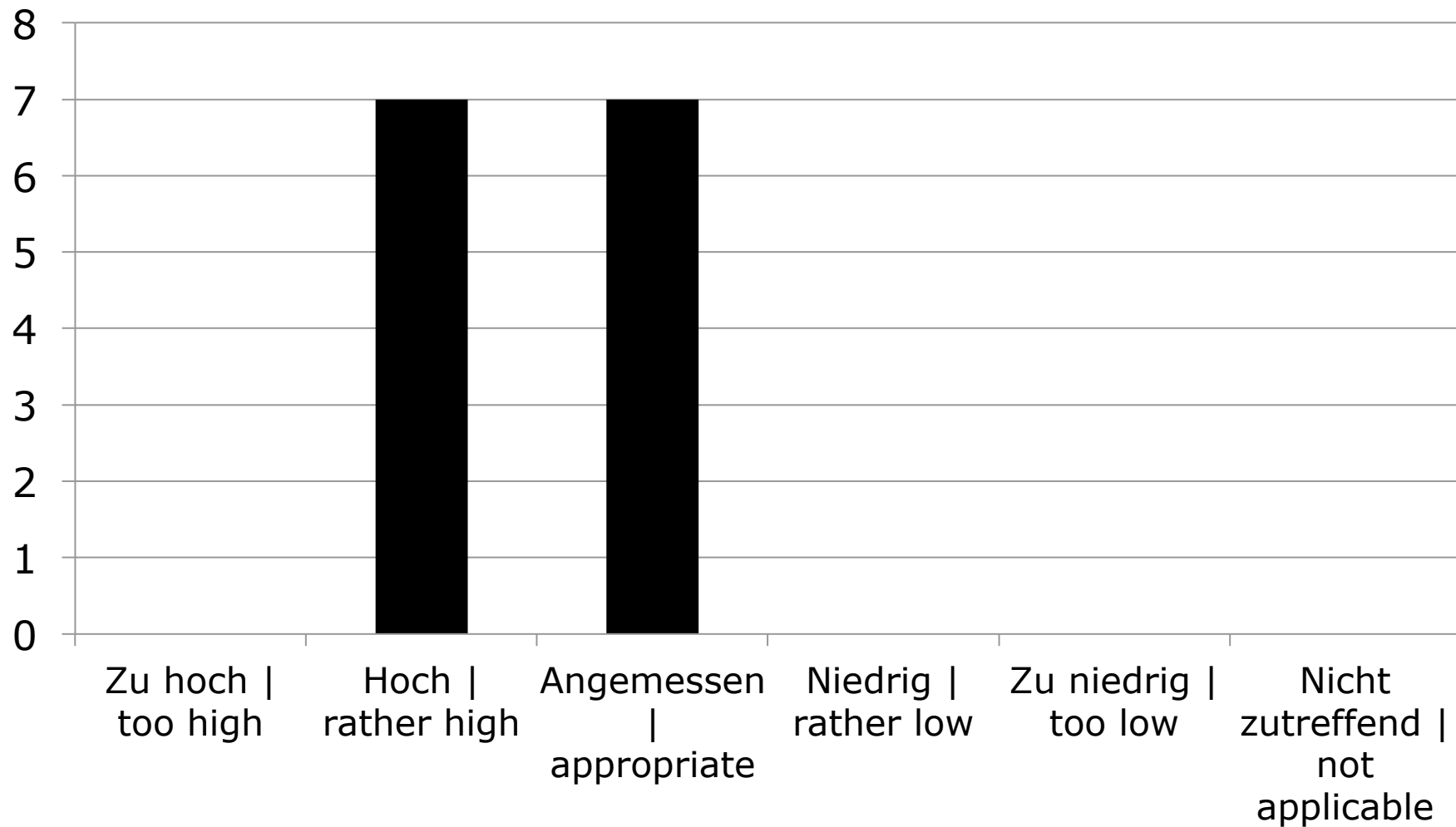
Sensor-Related Issues

- Efficient data association
- Sensor-related limitations such as:
- Poorly structured scenes
- Missing light for vision
- Monocular SLAM
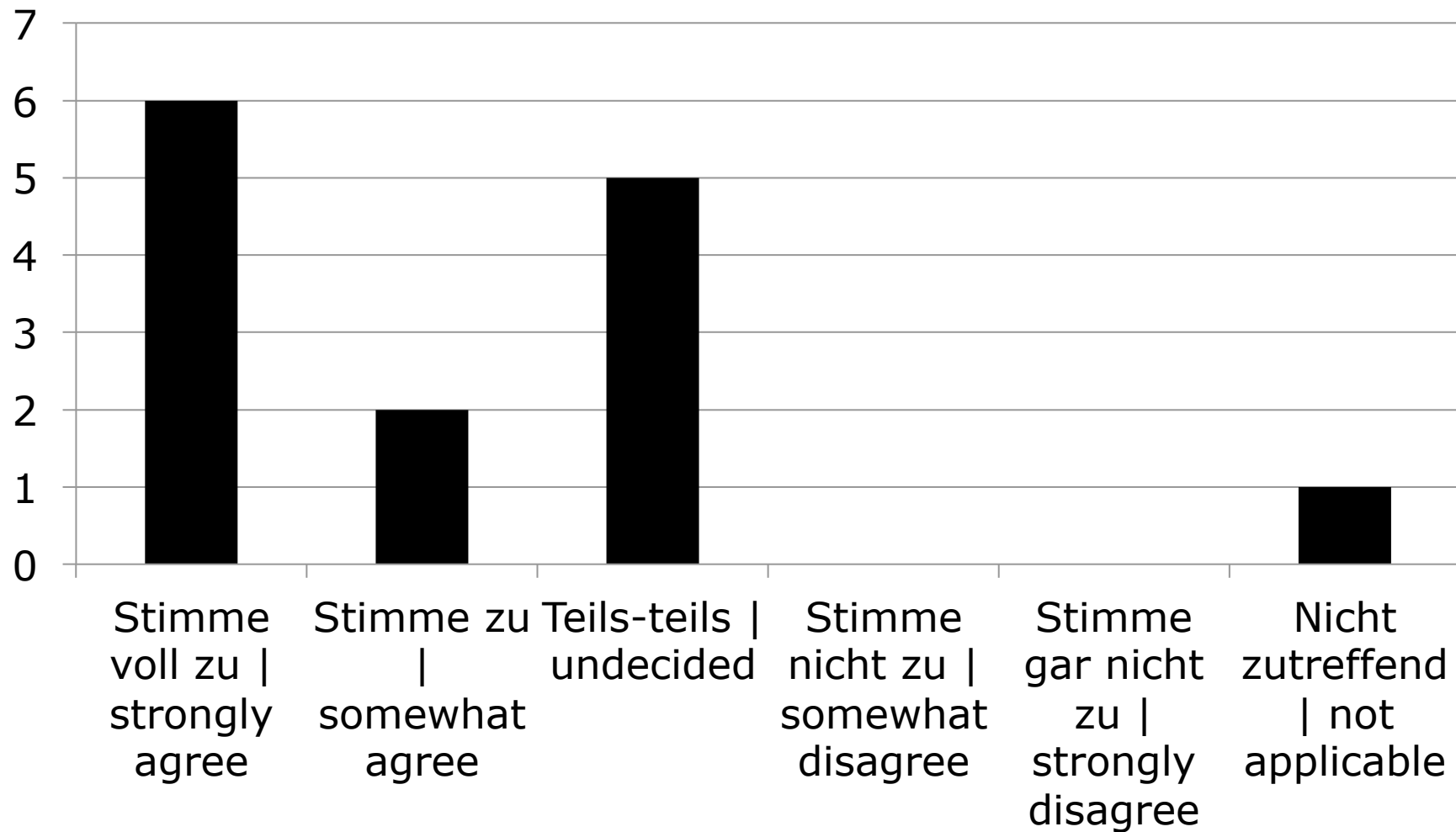 (in large environments)

Course Evaluation
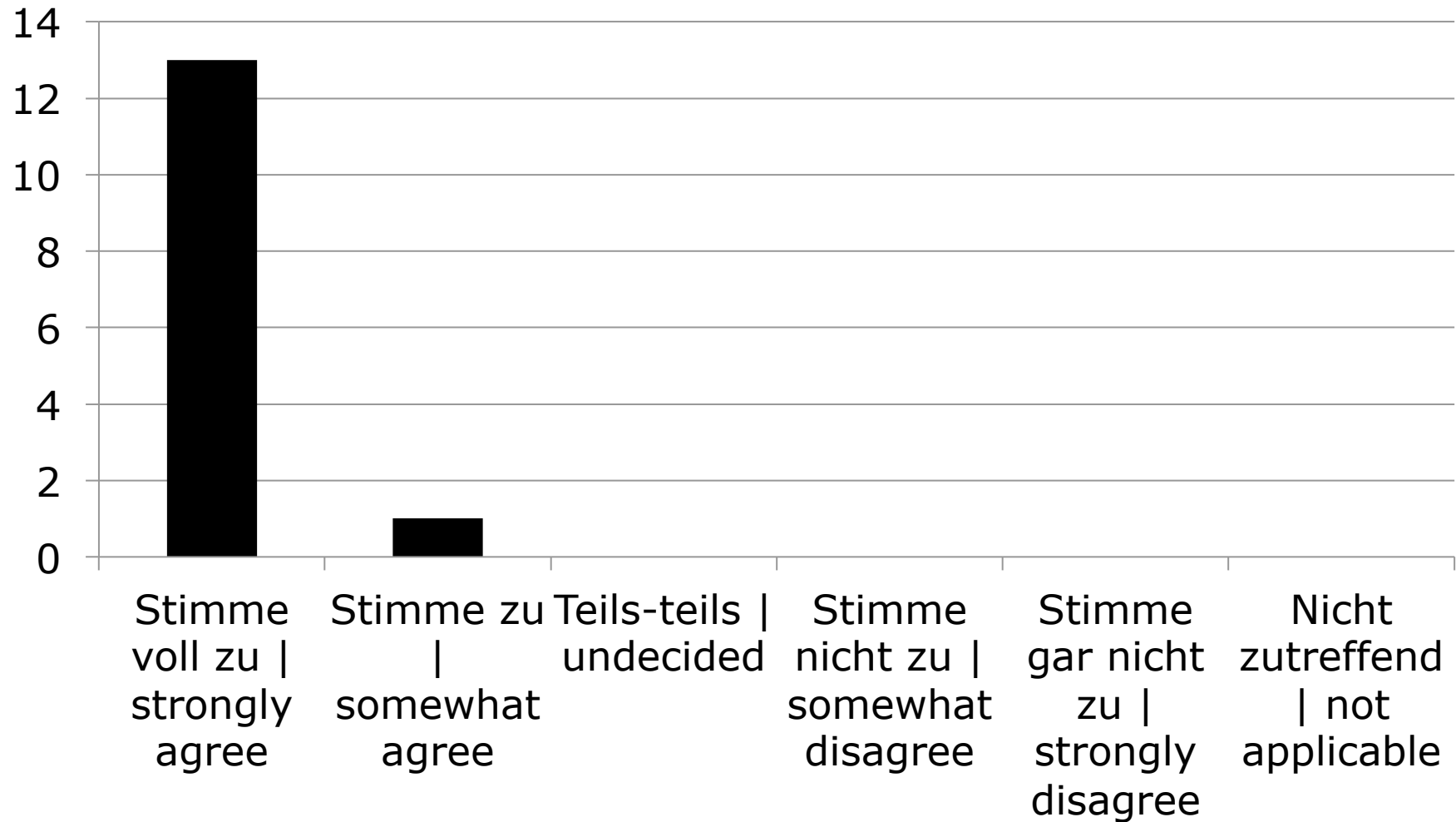
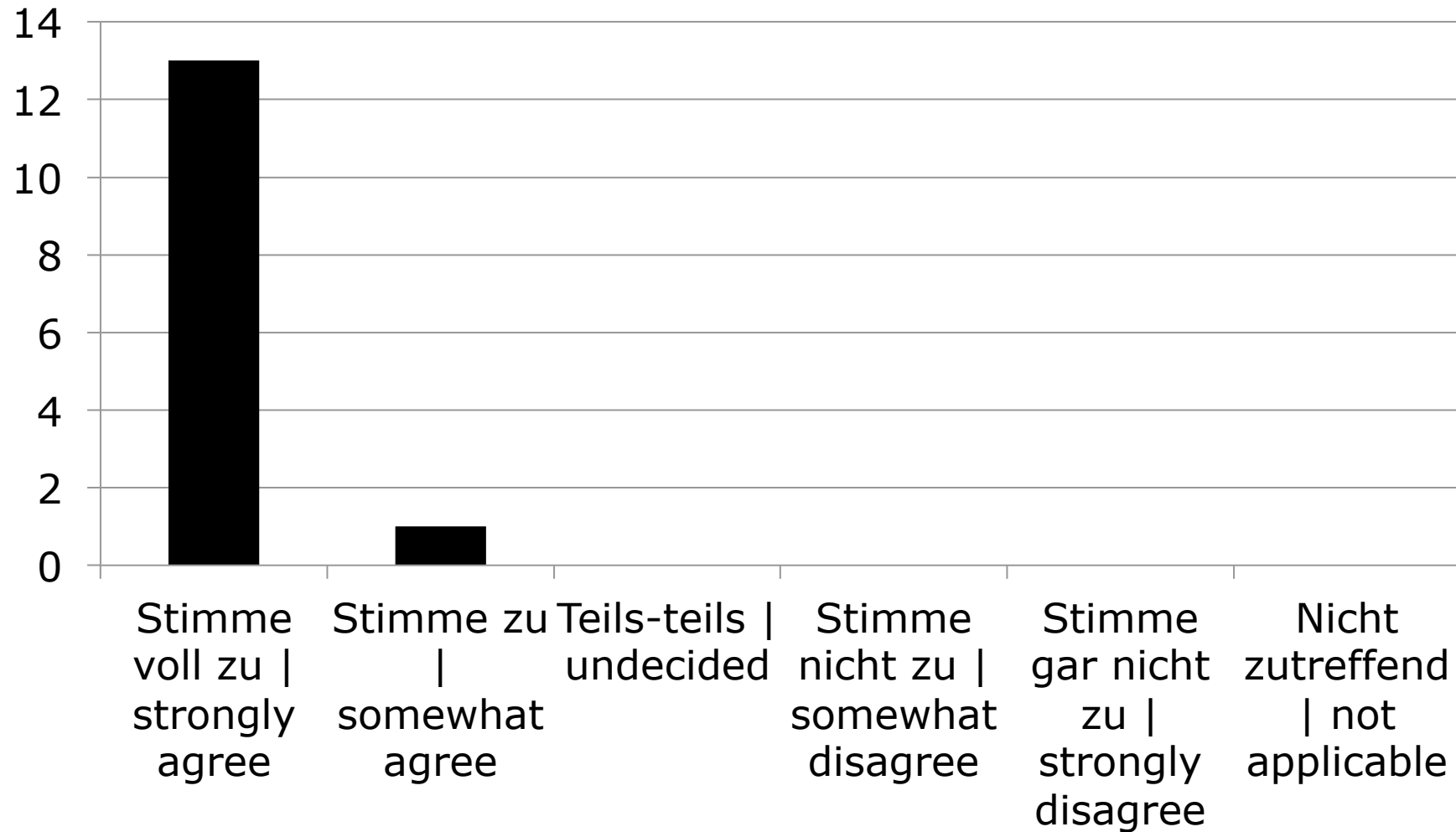# Learning Achievement
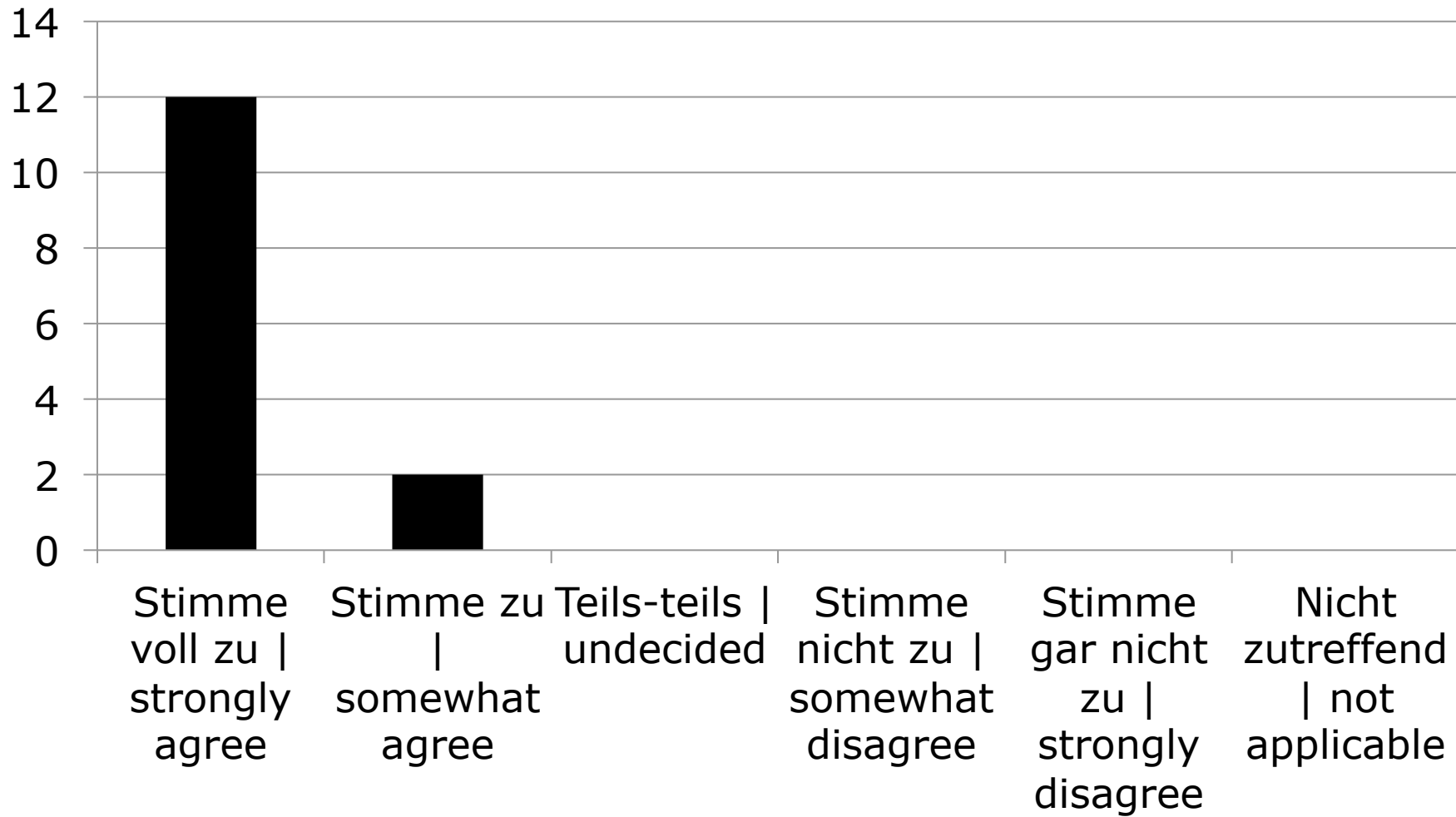
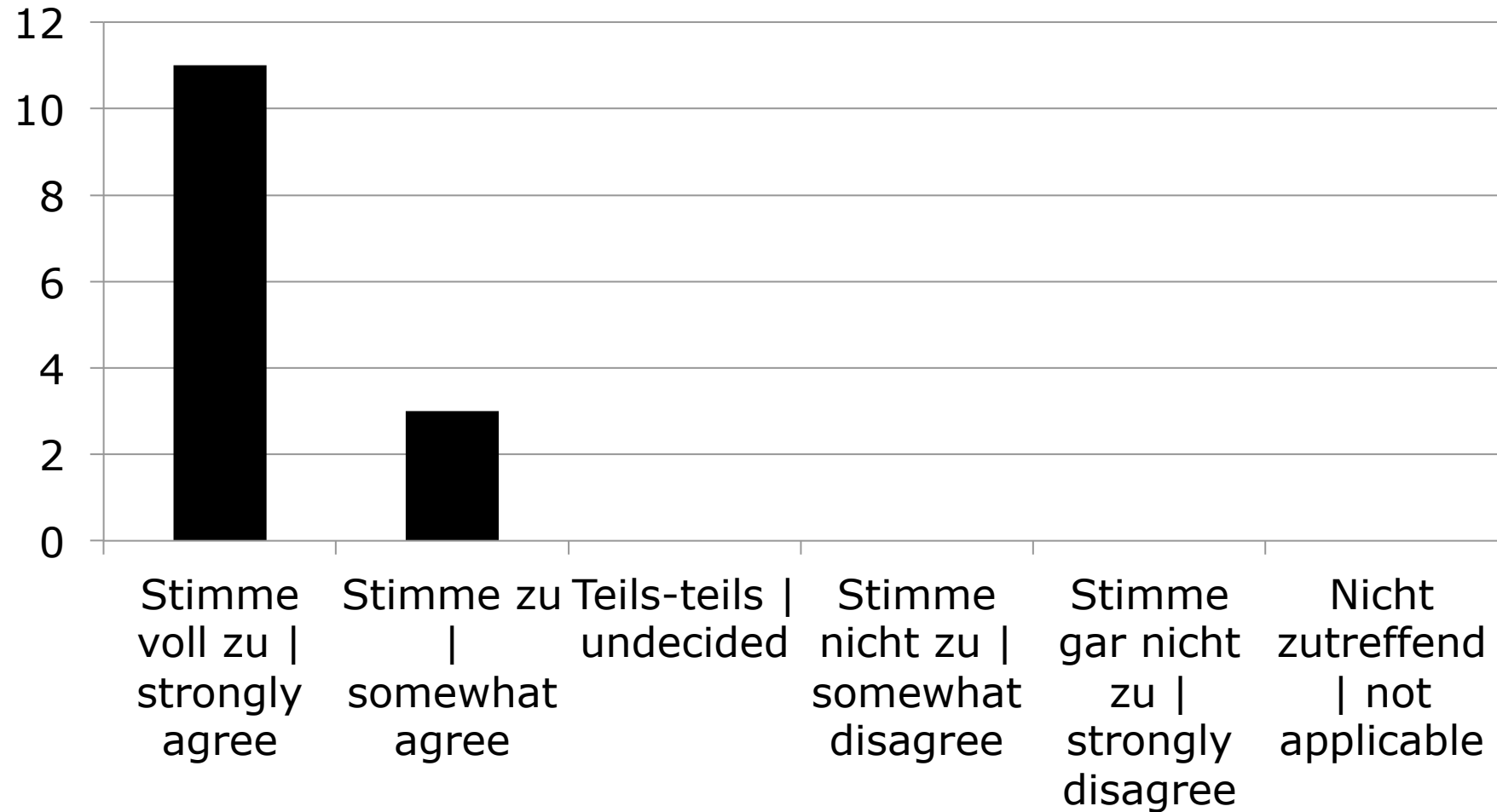# Content Level

Connections to Other Courses

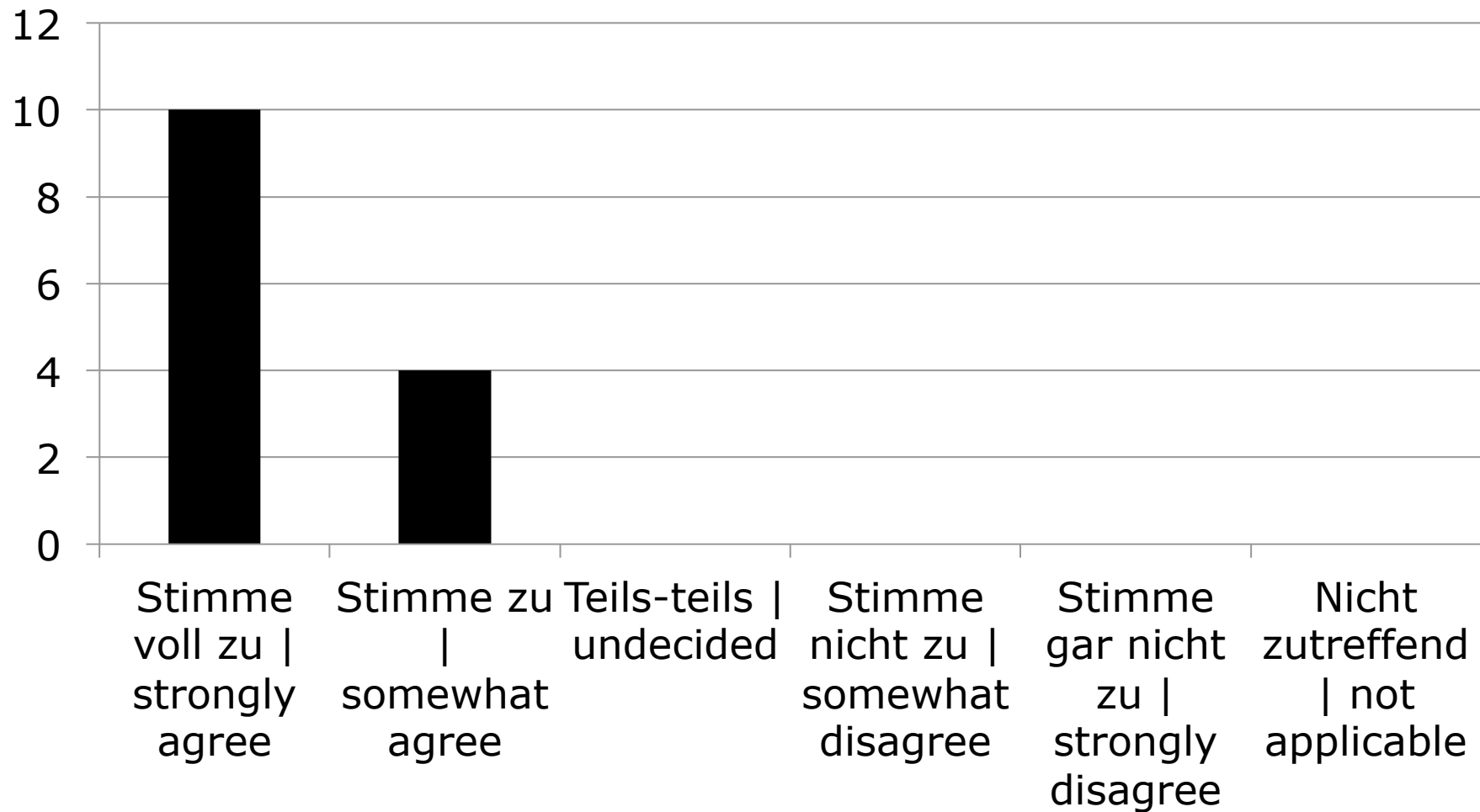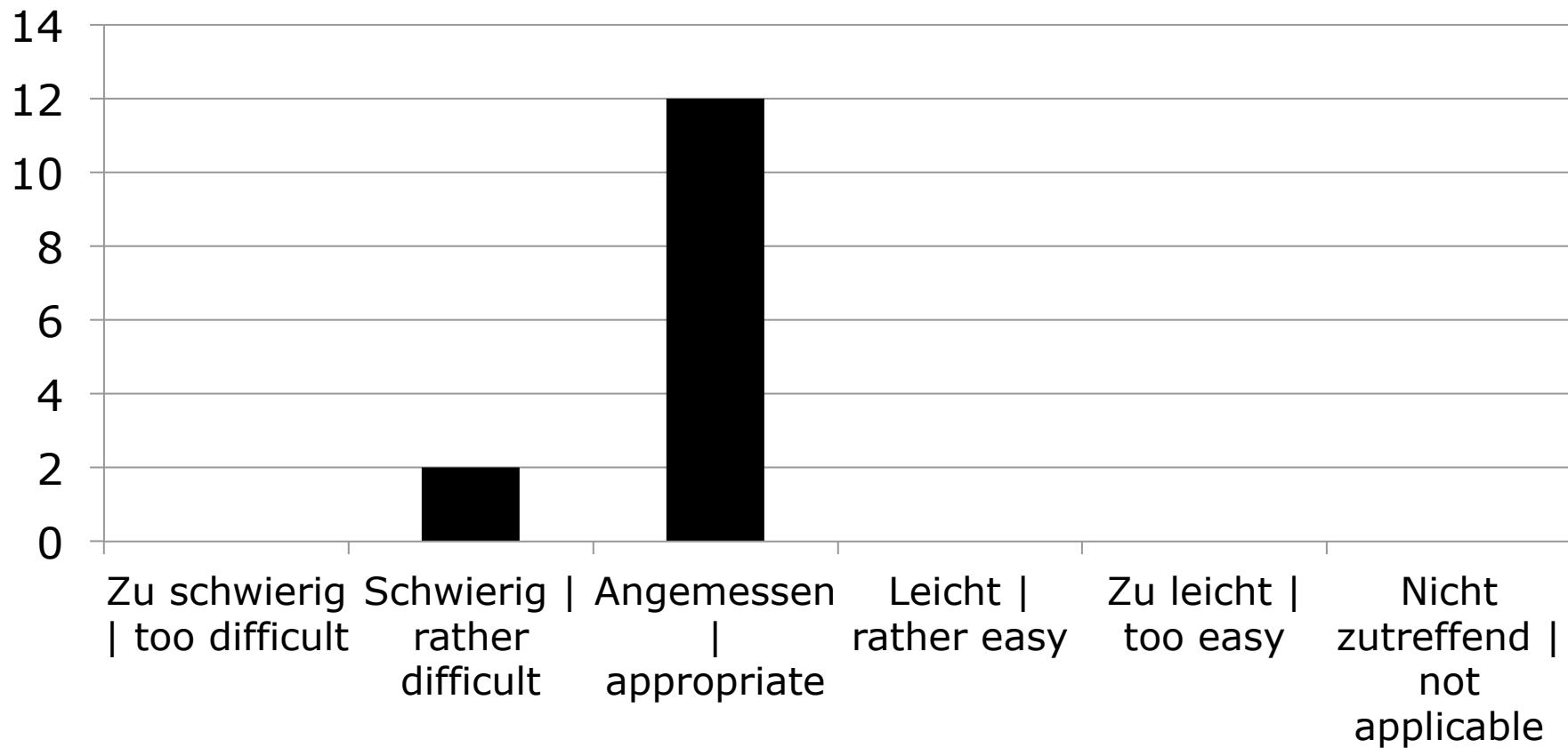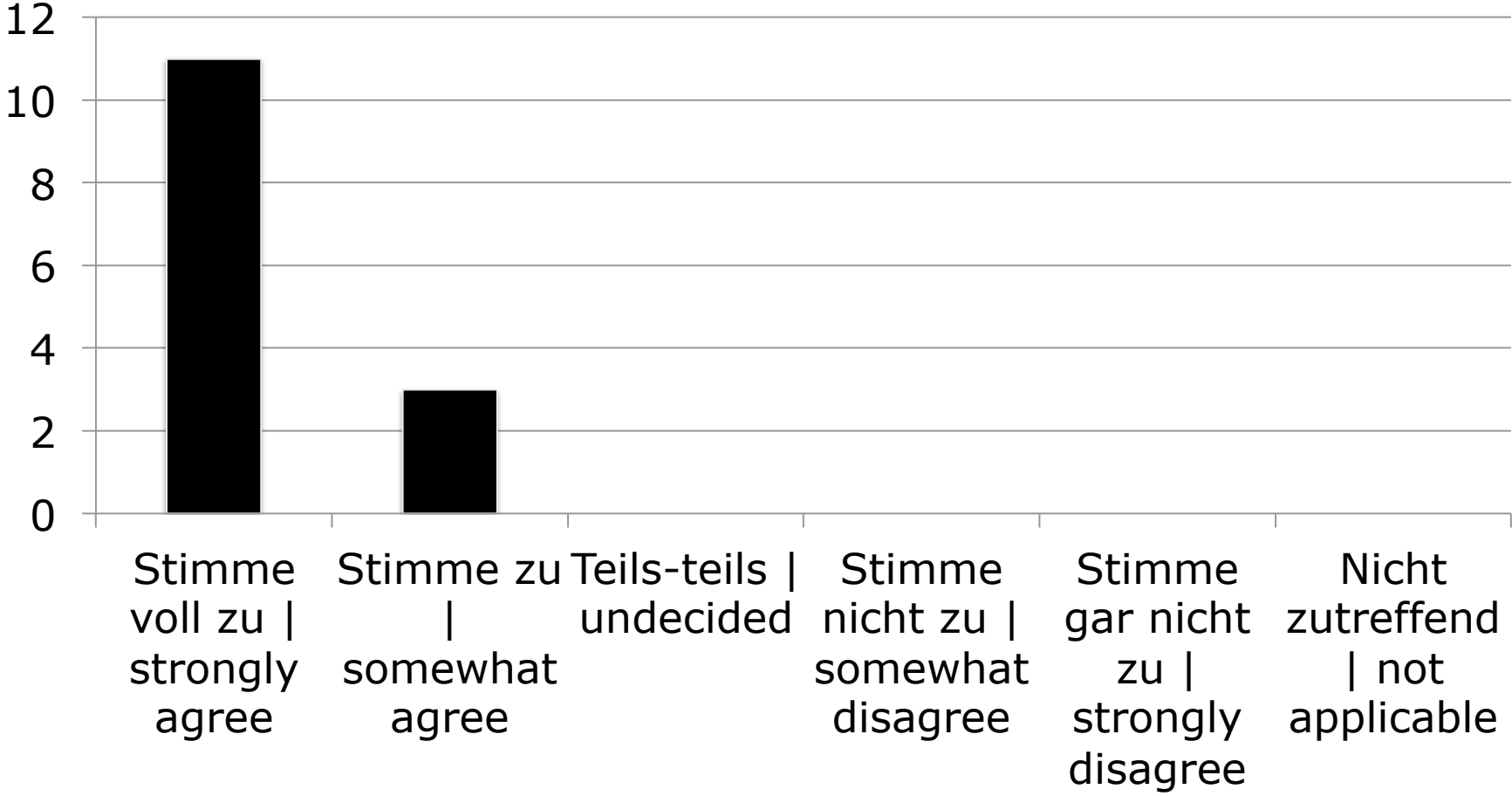# Central Theme is Clear

Quality of Slides & Material

Quality of Explanations

Response to Questions

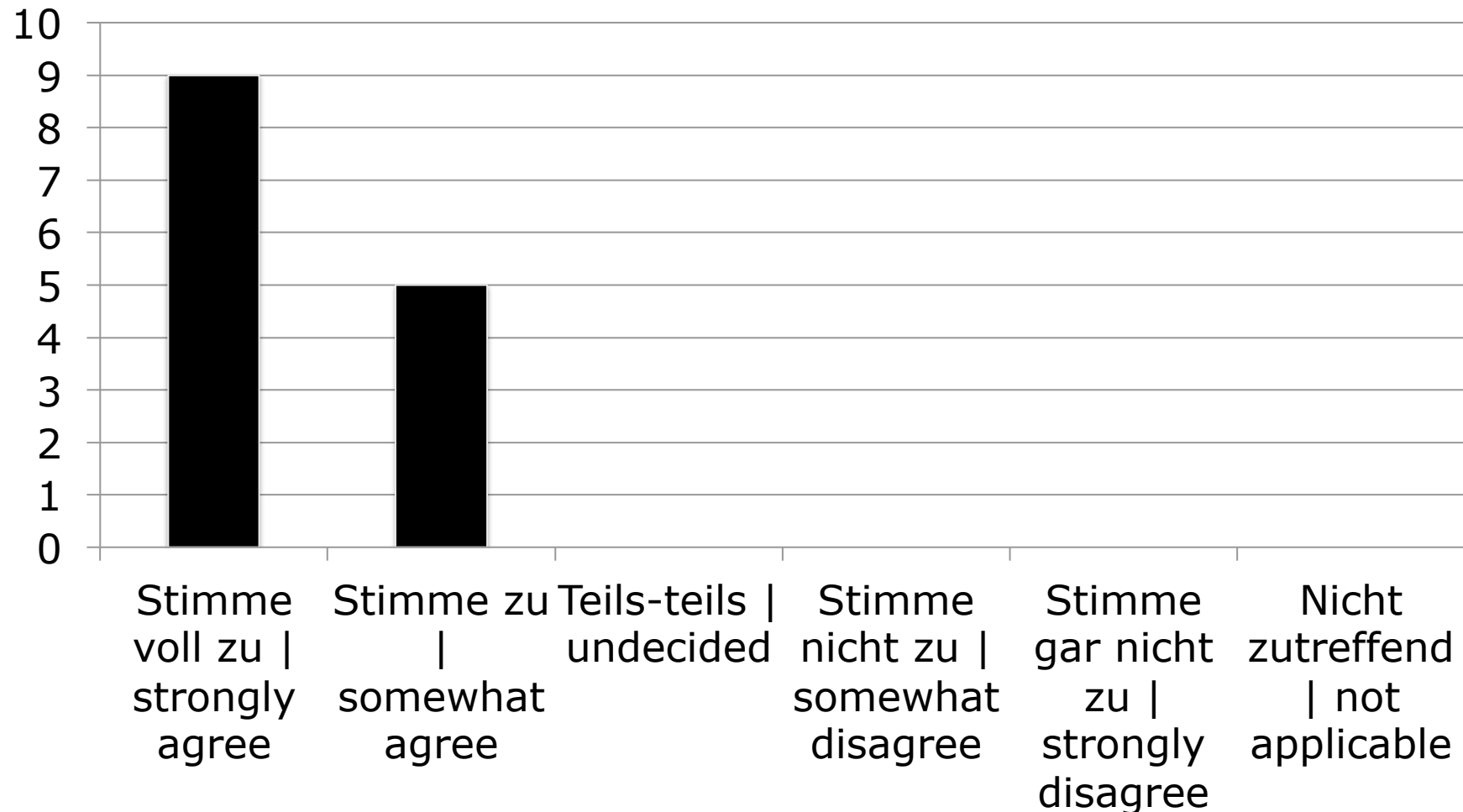# Difficulty of the Exercises

Tutorials are a Good Addition to the Lecture

Explanations of the Tutors Are Helpful

I liked...

- "Slides, material, recordings"
- "Explanations"
- "Discussions in the course"
- "Intermediate feedback"
- "Alignment of course and exercises"
- "No boring framework programming"
- "I really like the course and don't think there is too much space for improving it"

Could Be Improved...

- "Programming everything would be ideal although probably difficult…"
- "I would love to have a testing strategy whether the program works correctly"
- "I don't feel like the exercises have prepared me well for the exam (more non-programming exercises)"

Could Be Improved…

- "I would love to see more examples on how the theory fits to the final implementation and what are the most common pitfalls"
- "I would gladly give more time for a more extensive summary and introduction to each lecture and how that fits into the overall course"
- "Discuss more of the open research questions"

Course Evaluation

Thank you!

Which Topics Did You Miss?

(and what should be discarded then)

SS'13: Introduction to Mobile Robotics

Mondays 10-12 and Tuesdays 10-12

Good Luck for the Exam

(visit me or the tutors if you have
questions during the preparation)