

Incorporating chemical safety and security into the undergraduate curriculum

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Introduction

Juniata College is a small liberal arts college located in central Pennsylvania. Each year, approximately half of our entering students plan to study the sciences.

In our introductory laboratory courses, we have implemented the use of hazards analyses in order to emphasize the ability to identify hazards and take proper safety precautions. In working with our advanced students, we generally observed safe practices, but we suspected that students struggle to navigate our chemical inventory system and to correctly manage hazardous waste.

In order to assess the safety behaviors and attitudes of our students, we surveyed 128 introductory students and 31 advanced students at the end of the spring 2016 semester to evaluate areas of strength and places for improvement.

Introductory laboratory experience

Introductory coursework

- In the first semester, students learn and review safety information each week as part of a pre-lab assignment.
- In the second semester, each student completes a graded hazards analysis that is submitted at the beginning of each lab period.
- In both courses, instructors discuss pertinent hazards with students at the beginning of each lab period.

Survey results

- Hazards analyses generally were successful, although there is room for improvement in teaching students to interpret chemical hazards.
- Students feel prepared for their future lab experiences and agree that what they learned about safety was useful.

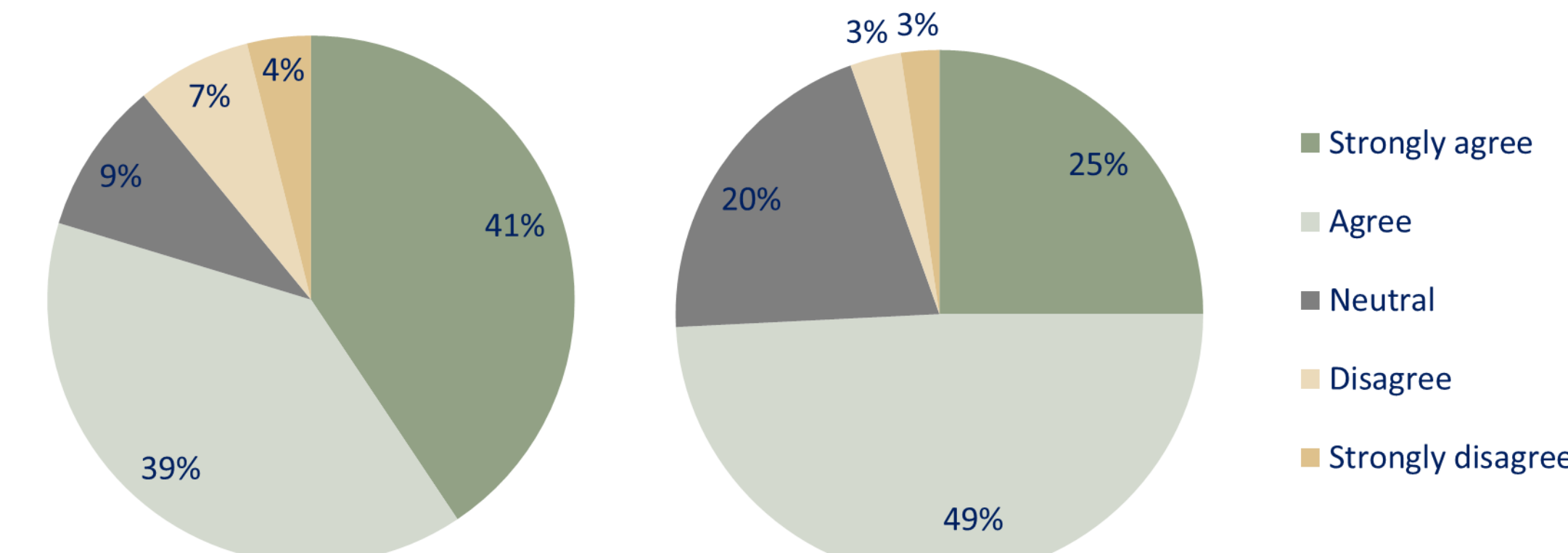


Figure 3. Response of introductory students to the statement, "Completion of the hazards analysis exercise helped me understand the hazards present in the laboratory."

Figure 4. Response of introductory students to the statement, "I am comfortable interpreting chemical hazard information."

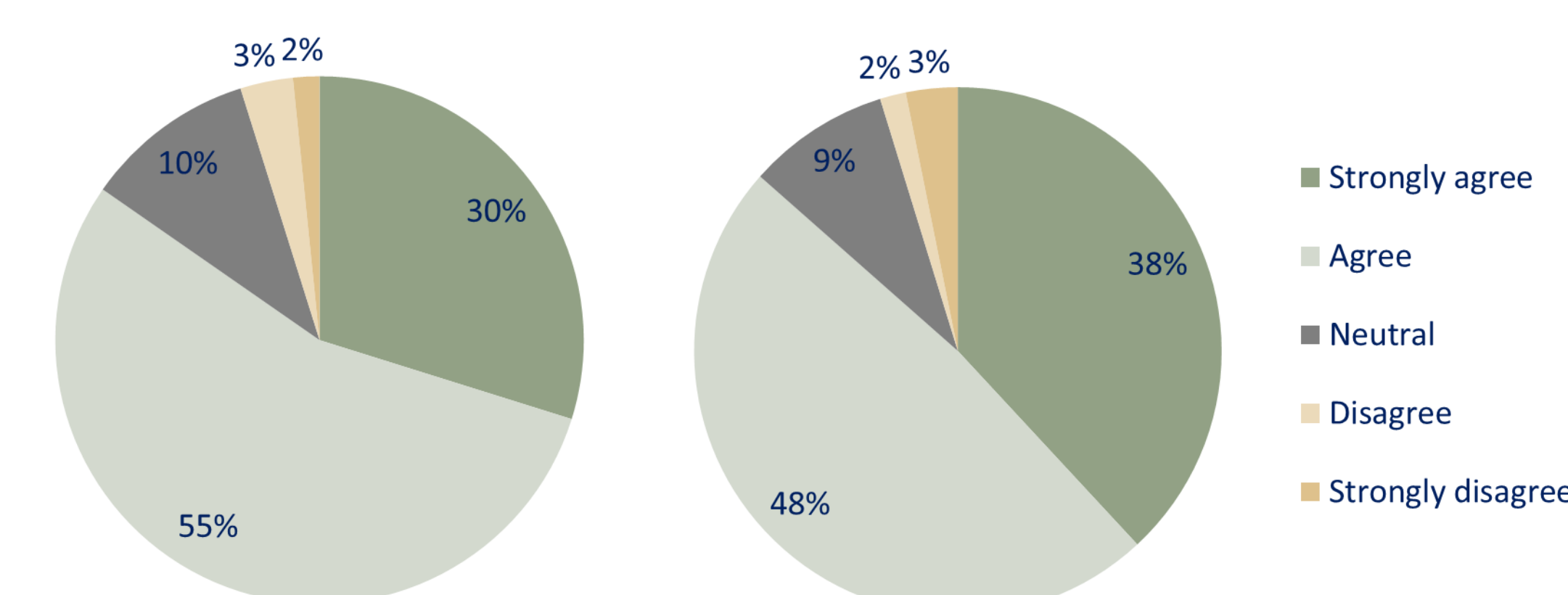


Figure 5. Response of introductory students to the statement, "I am confident that my safety training has prepared me for my future laboratory experiences."

Figure 6. Response of introductory students to the statement, "I expect that the safety skills I learned this semester will benefit me in the future."

Hazards analysis

Students complete hazards analyses beginning in the first year. They are designed to help extract critical information from SDS. Hazards analyses are completed in most laboratory classes and some research groups.

Chemical hazards:

Chemical name, if solution, include concentration. If solvent is not water, also list solvent separately	Chemical characteristics						Human health hazards															
	Physical state	Corrosive	Flammable	Oxidizer	Other (describe)	Signal word/danger	Oral	Dermal acute tox.	Skin corrosion	Eyes	Inhalation	Other										
							Fatal or toxic: H300, H301	Harmful: H302	May be harmful: H303	Fatal or toxic: H310, H311	May be harmful: H312	Harmful: H313	May be harmful: H314	Severe skin burn: H314	Skin irritation: H315	Mild skin irritation: H316	Serious damage: H330 or H332	Serious irritation: H331	Fatal or toxic: H330, H331	Harmful: H332	May be harmful: H333	Describe, Carcinogen, etc.

Physical and procedural hazards:

Personal protective equipment used during procedure: Describe which specific steps require PPE. Eye protection and lab coats are expected for all steps and do not need to be listed.

Waste disposal:

Chemical or solution: give all components and approximate concentrations	Hazardous waste containers			Non-hazardous waste					
	Aqueous waste	Organic, non-halogenated	Organic, halogenated	Solid waste	Drain	Neutralize, then drain	Disinfect, then drain	Trash	Comments or other

Summary results

Data shows that students are aware of chemical hazards and recognize the value of safe laboratory practices.

90% of respondents indicated they always or often consider relevant chemical and physical hazards before starting an experiment.

87% of introductory students and 65% of advanced students agreed or strongly agreed that Juniata has a culture of safety.

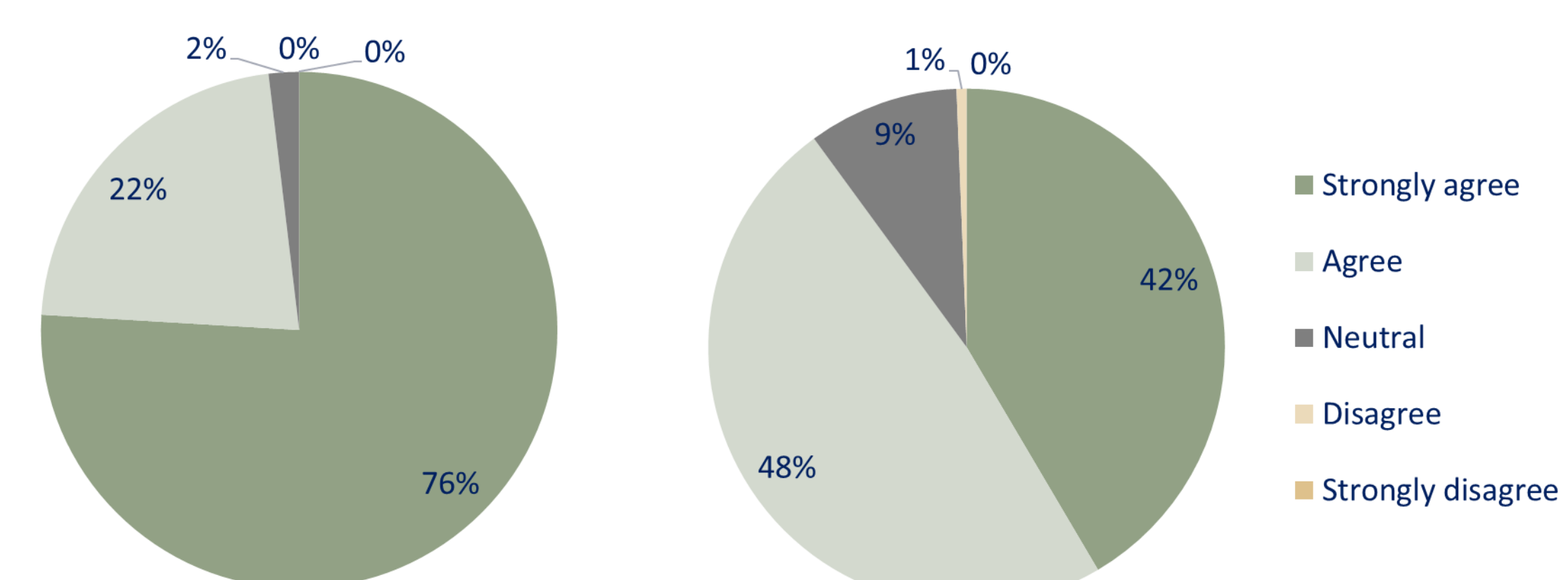


Figure 1. Response of introductory and advanced students to the statement, "It is important to understand the relevant chemical and physical hazards before starting an experiment."

Figure 2. Response of introductory and advanced students to the statement, "Juniata has a culture of chemical safety."

Advanced laboratory experience

Advanced coursework

- Because chemistry majors in advanced laboratory courses often devise their own experiments in small groups, they must evaluate hazards independently.
- Each academic year ~25 students participate in independent laboratory research with a faculty member.
- Hazards analyses are formally completed in some of these course and research experiences.

Survey results

- Students acknowledge the importance of waste management but do not utilize the best resource for categorizing waste.
- Students understand the value of effective chemical inventory systems but feel that our current system is inadequate.

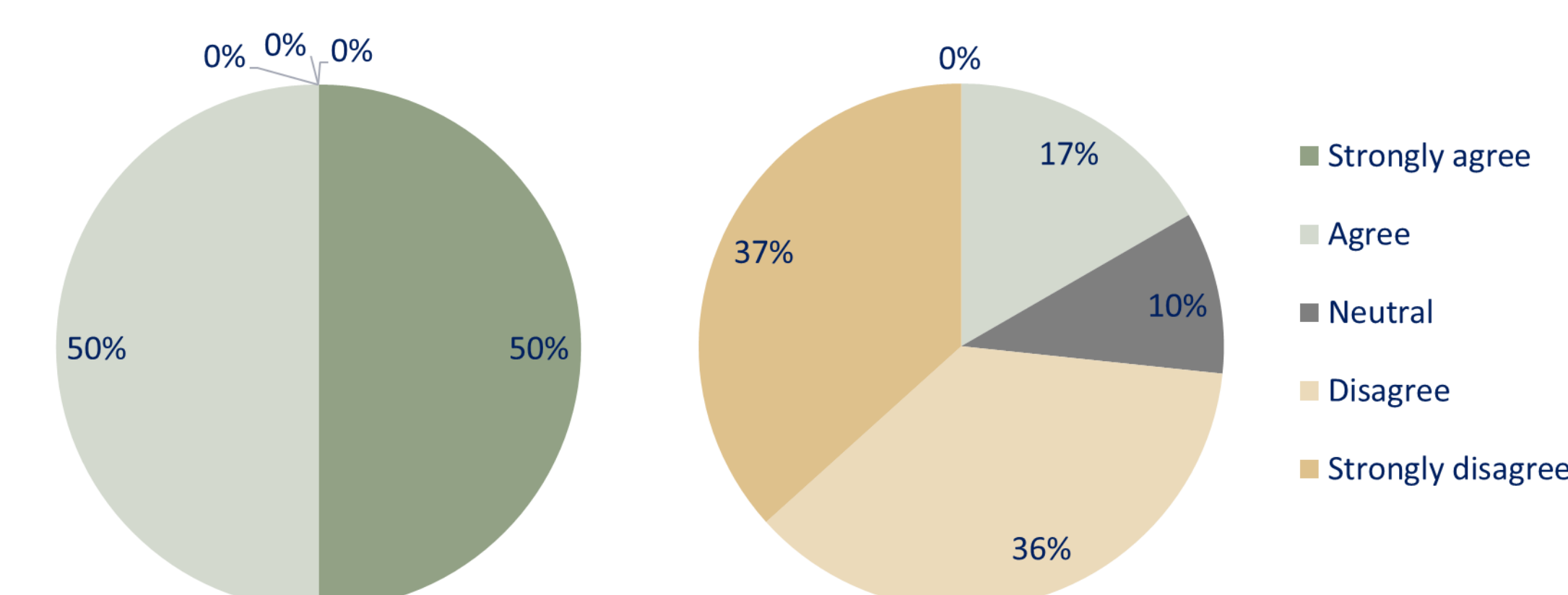


Figure 7. Response of advanced students to the statement, "Improper segregation of chemical waste is a safety hazard."

Figure 8. Response of advanced students to the statement, "If I am unsure how to dispose of chemical waste, I consult Juniata's chemical hygiene plan."

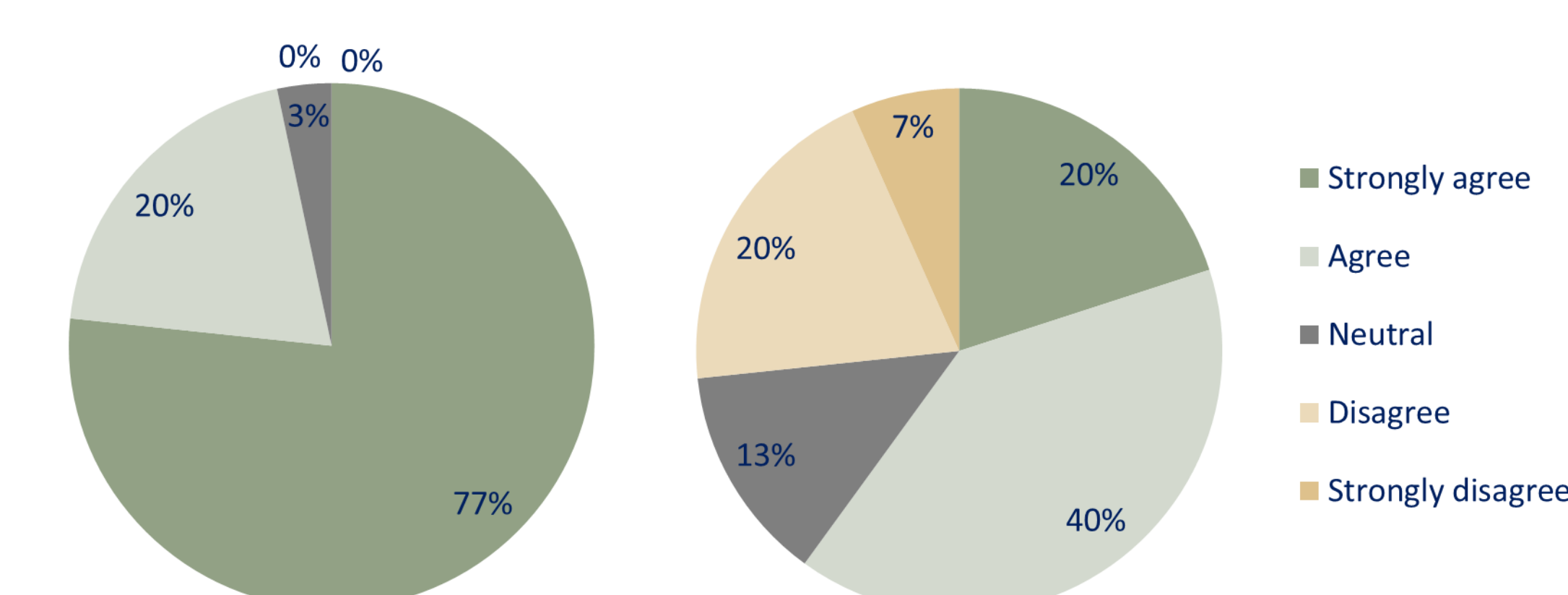


Figure 9. Response of advanced students to the statement, "An organized chemical inventory promotes laboratory safety."

Figure 10. Response of advanced students to the statement, "I am concerned by the level of organization of Juniata's chemical inventory."

Ongoing work

Considering the success at the introductory level, hazards analyses will be implemented through the advanced laboratory curriculum.

Responsible waste disposal strategies are being more intentionally integrated into coursework and research labs for the first time in fall 2016.

During spring and summer 2016, our department updated our inventory with more detailed location information and instituted a new check-in/check-out system for chemicals.

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