

**Argument visualisation
improves analytical
reasoning and argument
understanding**

Introduction

Method

Results

Discussion

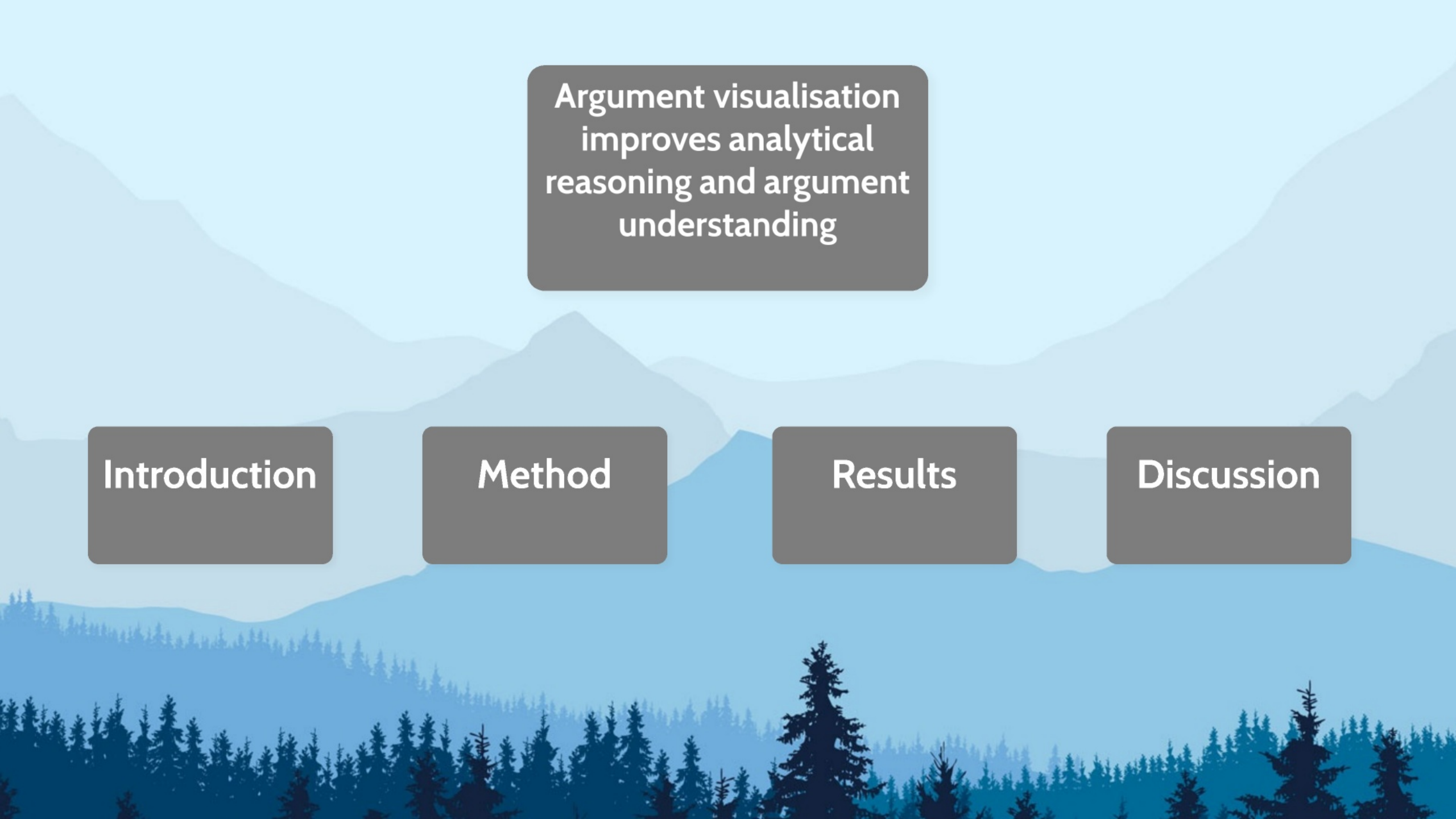
ARTICLE OPEN

Improving analytical reasoning and argument understanding: a quasi-experimental field study of argument visualization

Simon Cullen^{1,2}, Judith Fan³, Eva van der Brugge⁴ and Adam Elga¹

The ability to analyze arguments is critical for higher-level reasoning, yet previous research suggests that standard university education provides only modest improvements in students' analytical-reasoning abilities. What pedagogical approaches are most effective for cultivating these skills? We investigated the effectiveness of a 12-week undergraduate seminar in which students practiced a software-based technique for visualizing the logical structures implicit in argumentative texts. Seminar students met weekly to analyze excerpts from contemporary analytic philosophy papers, completed argument visualization problem sets, and received individualized feedback on a weekly basis. We found that seminar students improved substantially more on LSAT Logical Reasoning test forms than did control students ($d = 0.71$, 95% CI: [0.37, 1.04], $p < 0.001$), suggesting that learning how to visualize arguments in the seminar led to large generalized improvements in students' analytical-reasoning skills. Moreover, blind scoring of final essays from seminar students and control students, drawn from a parallel lecture course, revealed large differences in favor of seminar students ($d = 0.87$, 95% CI: [0.26, 1.48], $p = 0.005$). Seminar students understood the arguments better, and their essays were more accurate and effectively structured. Taken together, these findings deepen our understanding of how visualizations support logical reasoning and provide a model for improving analytical-reasoning pedagogy.

npj Science of Learning (2018)3:21 ; doi:10.1038/s41539-018-0038-5



**Argument visualisation
improves analytical
reasoning and argument
understanding**

Introduction

Method

Results

Discussion

Argument visualisation
improves analytical reasoning
and argument understanding

because

because

because

because

because

because

because

Guide visual
attention to
salient
elements
(previous
studies)

Bind
elements
that share a
common
function
(previous
studies)

Reflect a
hierarchical
structure of
arguments
(previous
studies)

Visual
explanations
may help to
clearly convey
what students
understand
(previous
studies)

They can facilitate
collaborative
problem solving
(previous studies)

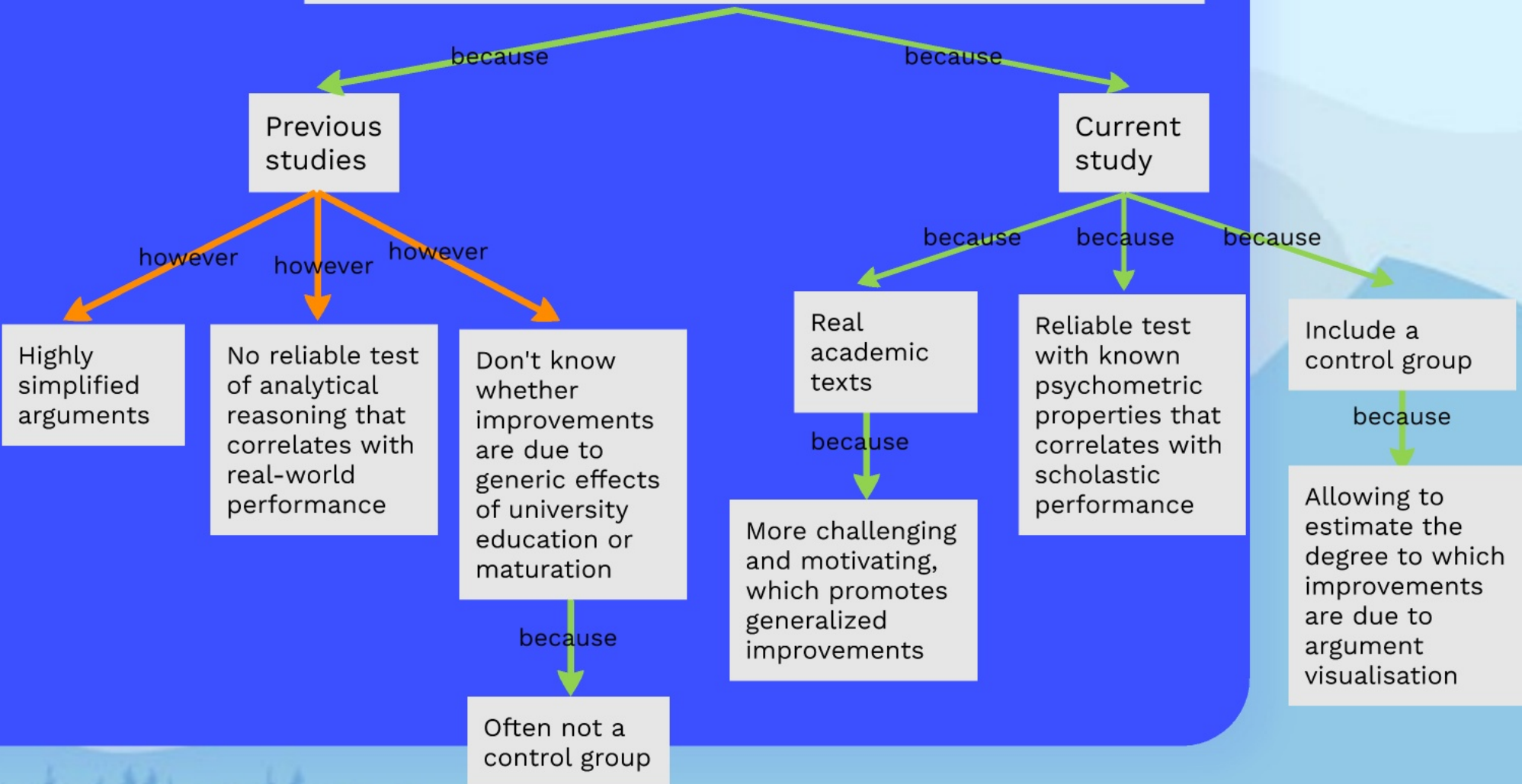
because

Maps can be
easily shared
with others

Improved
feedback
from
instructors
(previous
studies)

Current study

Argument visualisation improves analytical reasoning and argument understanding



Argument visualisation
improves analytical reasoning
and argument understanding

because

because

because

because

because

because

because

Guide visual
attention to
salient
elements
(previous
studies)

Bind
elements
that share a
common
function
(previous
studies)

Reflect a
hierarchical
structure of
arguments
(previous
studies)

Visual
explanations
may help to
clearly convey
what students
understand
(previous
studies)

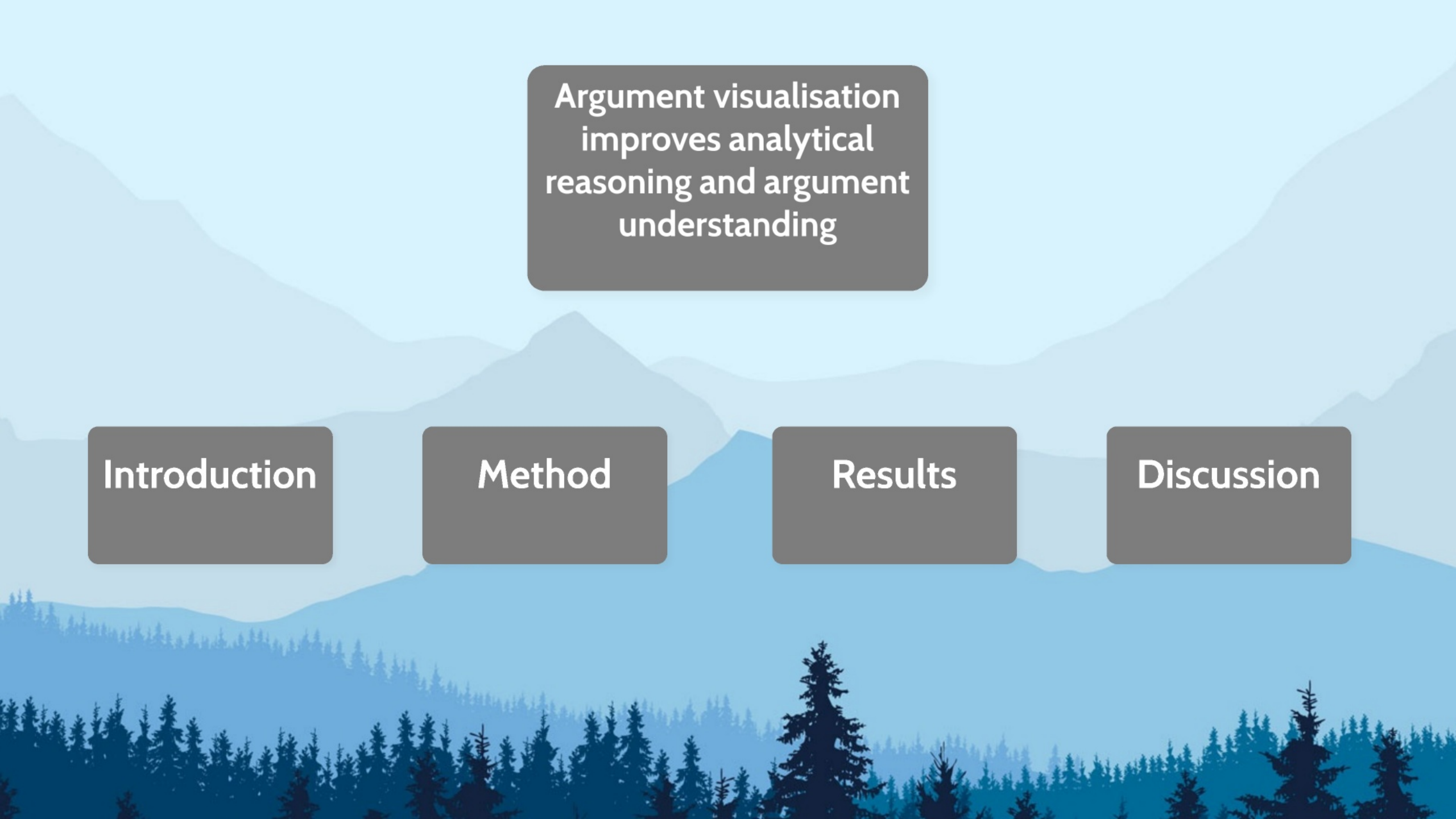
They can facilitate
collaborative
problem solving
(previous studies)

because

Maps can be
easily shared
with others

Improved
feedback
from
instructors
(previous
studies)

Current study



**Argument visualisation
improves analytical
reasoning and argument
understanding**

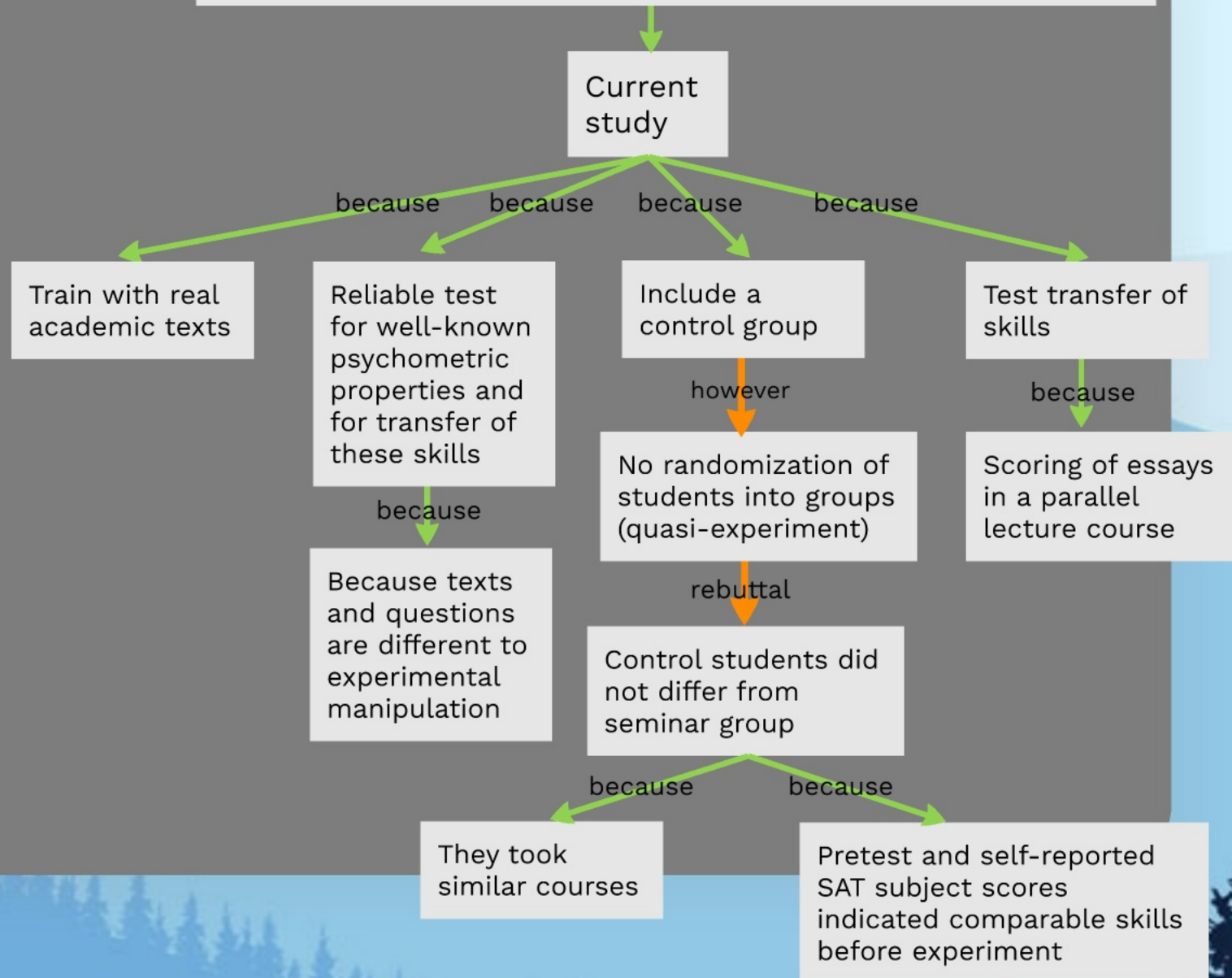
Introduction

Method

Results

Discussion

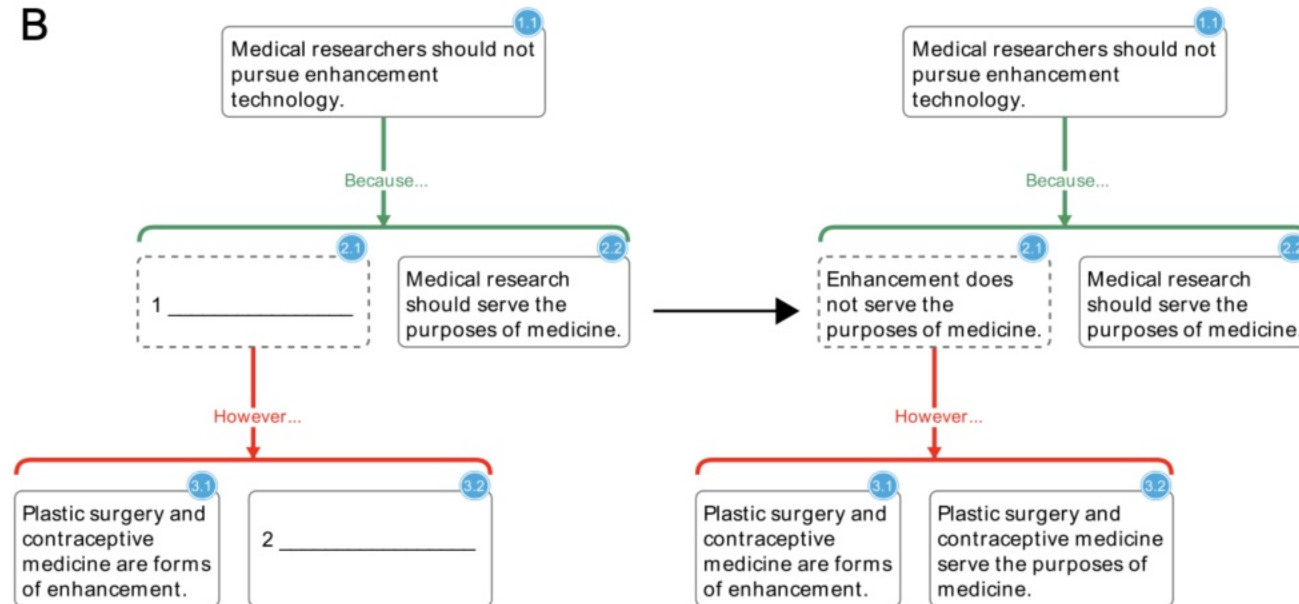
Argument visualisation improves analytical reasoning and argument understanding



A

Medical enhancement, like radical life-extension technology, isn't about curing illness or reducing people's discomfort; it's about taking healthy people and making them better — smarter, kinder, happier, longer-lived, more attractive, more athletic. People sometimes argue that medical researchers should not pursue enhancement technology because such technology goes beyond the purpose of medicine. But consider that many already accepted medical treatments are not intended to cure illness or reduce discomfort: plastic surgery and contraceptive medication are just two examples.

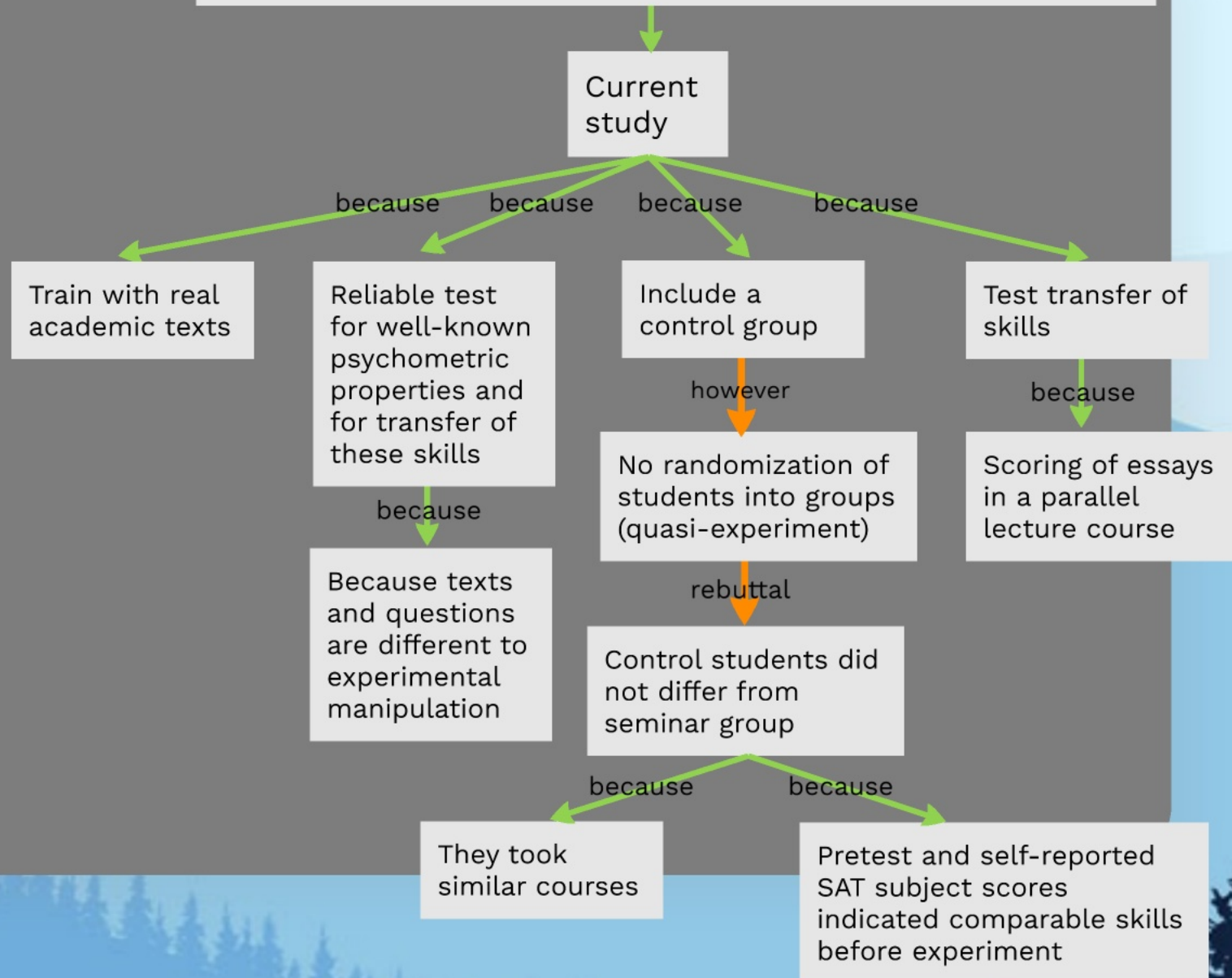
B



'Most texts used in the seminar were drawn from professional journals and books (e.g., Judith Jarvis Thomson's "A Defense of Abortion," Philippa Foot's "Killing and Letting Die," David Lewis' "Are We Free to Break the Laws?," and so forth.)'

Fig. 3 a Sample text. b Sample fill-in-the-blank exercise from an introductory problem set assigned early in the semester. Dashed borders mark claims which are implicit in the text (i.e., charitable assumptions required by the argument). Supporting reasons are represented by horizontal green brackets labeled "because"; objections are represented by horizontal red brackets labeled "however"

Argument visualisation improves analytical reasoning and argument understanding



Law admission score test

Logical reasoning forms

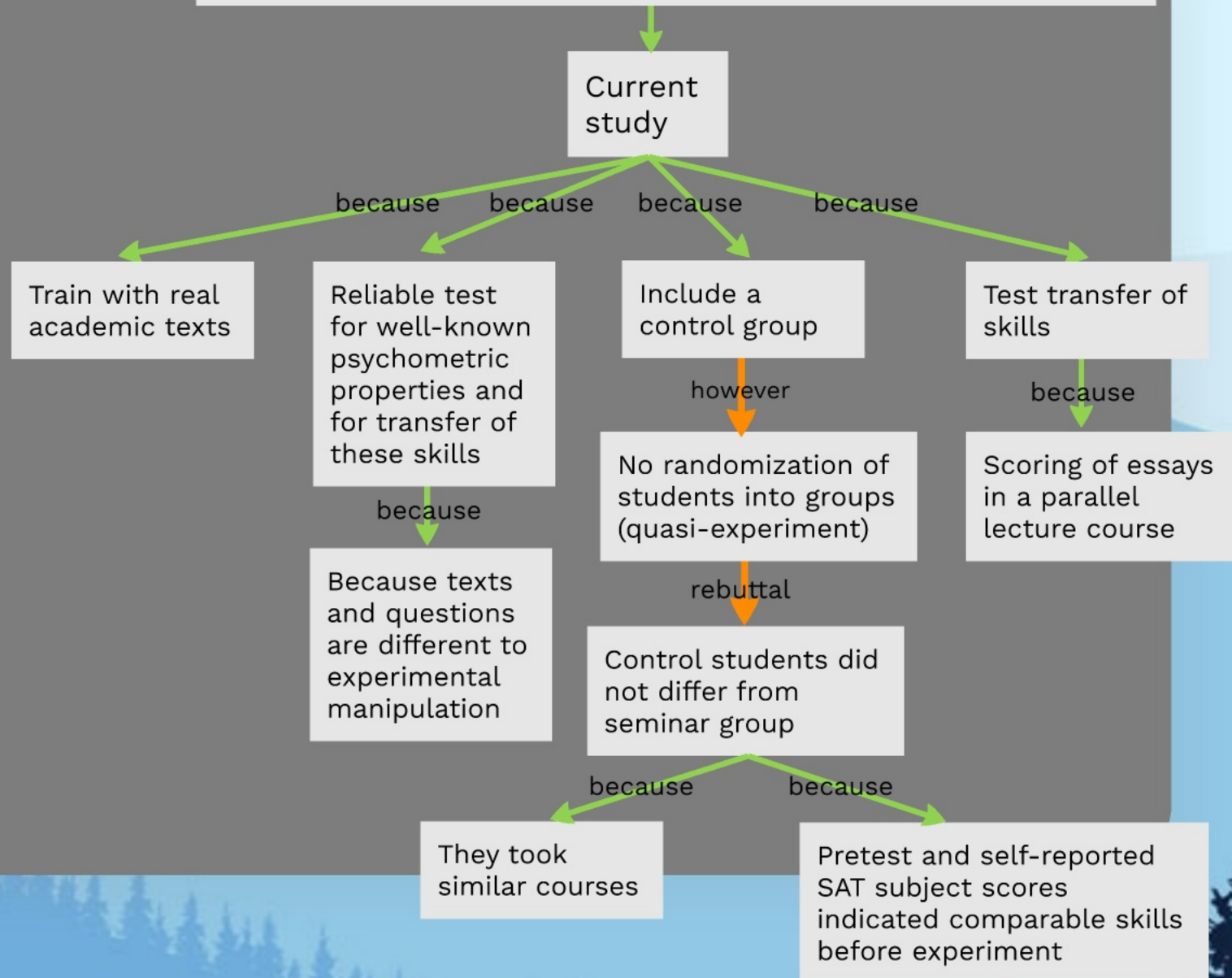
Laird: Pure research provides us with new technologies that contribute to saving lives. Even more worthwhile than this, however, is its role in expanding our knowledge and providing new, unexplored ideas.

Kim: Your priorities are mistaken. Saving lives is what counts most of all. Without pure research, medicine would not be as advanced as it is.

Laird and Kim disagree on whether pure research

- A. derives its significance in part from its providing new technologies
- B. expands the boundaries of our knowledge of medicine
- C. should have the saving of human lives as an important goal
- D. has its most valuable achievements in medical applications
- E. has any value apart from its role in providing new technologies to save lives

Argument visualisation improves analytical reasoning and argument understanding



Seminar group

105 students

For one semester (in groups of approx. 15 students):

- Three activities each week
- Create visualisations of arguments, instructors provided assistance
- Students worked independently on problem sets requiring argument visualisation
- Students received 'detailed feedback on their work-in-progress'

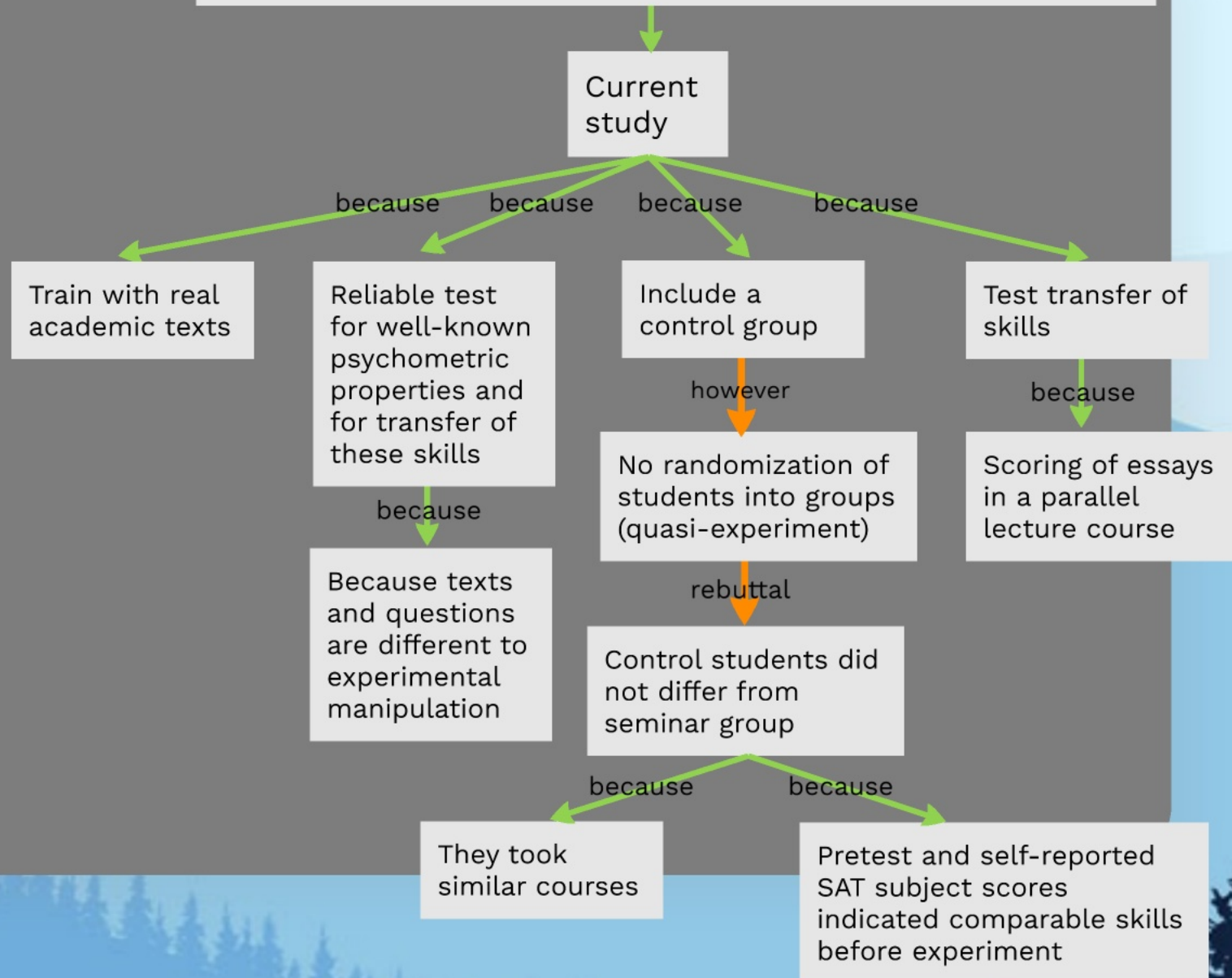
Control group

56 students

For one semester:

- Matured
- Generic effects of Princeton education

Argument visualisation improves analytical reasoning and argument understanding

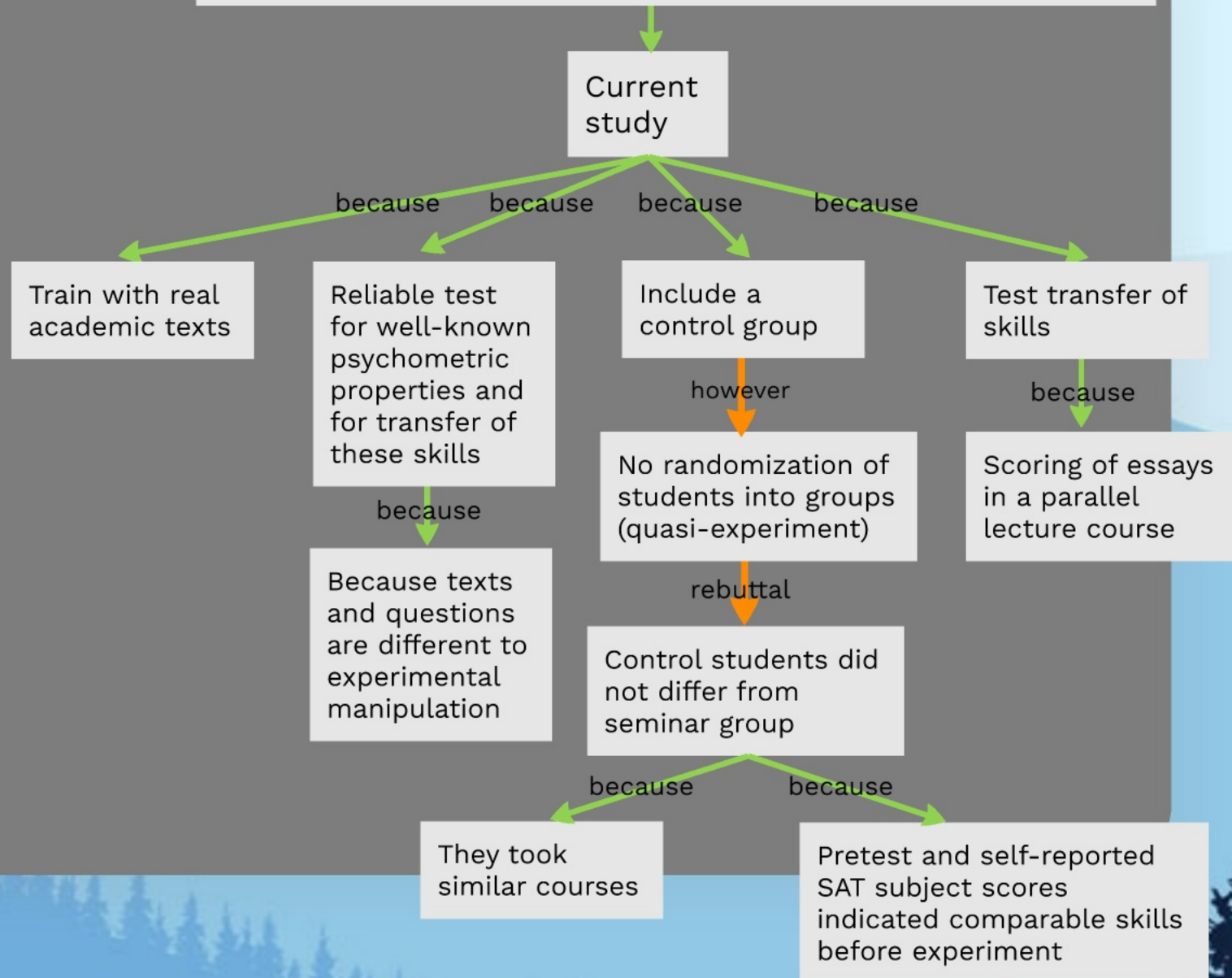


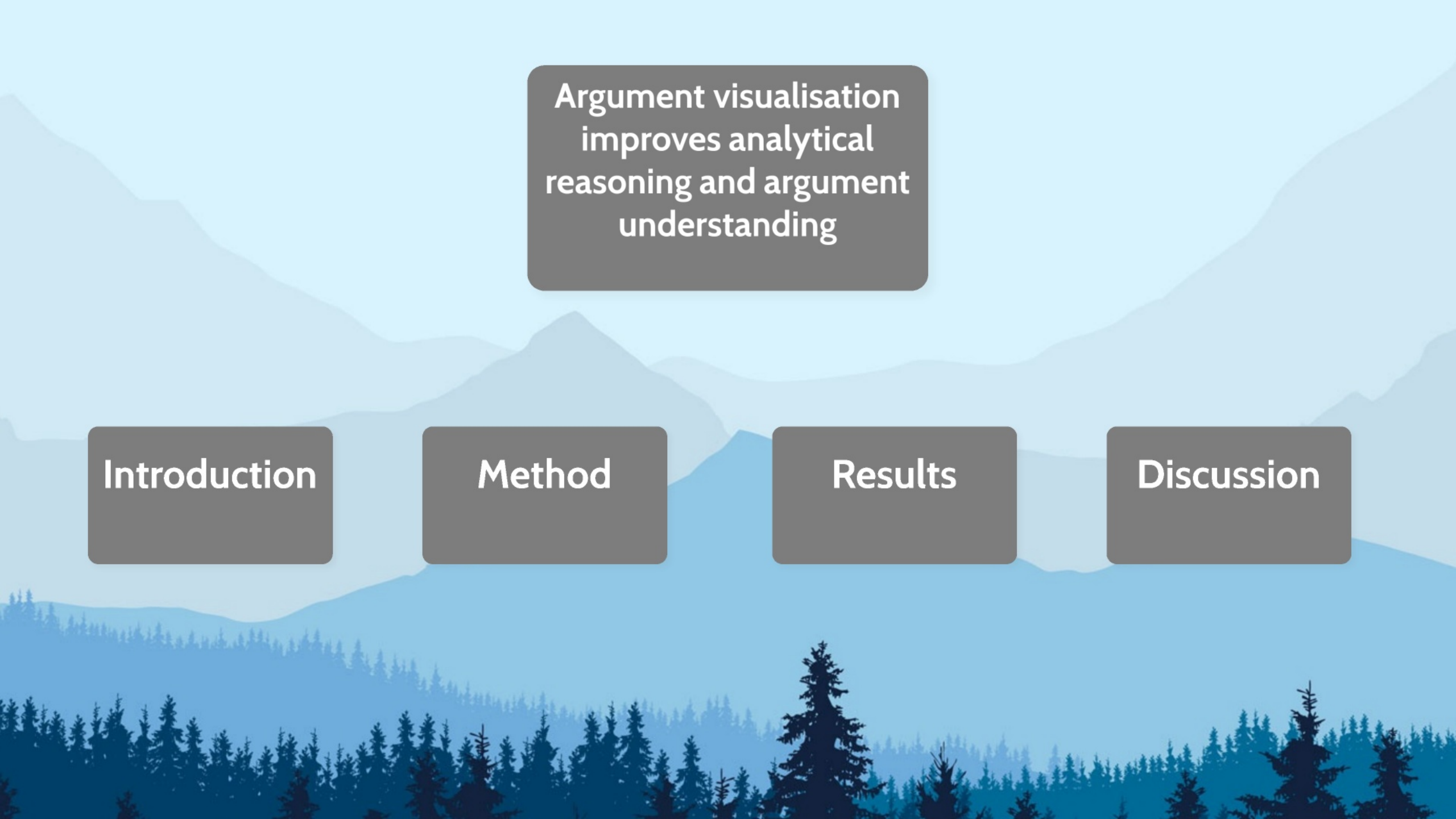
Transfer of skills

A grader blind to the hypothesis under study evaluated each essay using the following three-item scale:

1. How effectively structured is the essay?
2. How accurately presented are the relevant arguments?
3. How well does the student understand the relevant arguments?

Argument visualisation improves analytical reasoning and argument understanding





**Argument visualisation
improves analytical
reasoning and argument
understanding**

Introduction

Method

Results

Discussion

Argument visualisation improves analytical reasoning and argument understanding

Results

Participating in seminar led to improved LSAT

Seminar students had better analytical and composition skills in the context of real academic assignments

because

because

Seminar students performed better on posttest than pretest.

Control did not perform better on the posttest than they had on the pretest.

because

because

because

because

Seminar students structured essays more effectively

Seminar students presented arguments more accurately

Seminar students understood relevant arguments better

Seminar students received higher grades for their essays

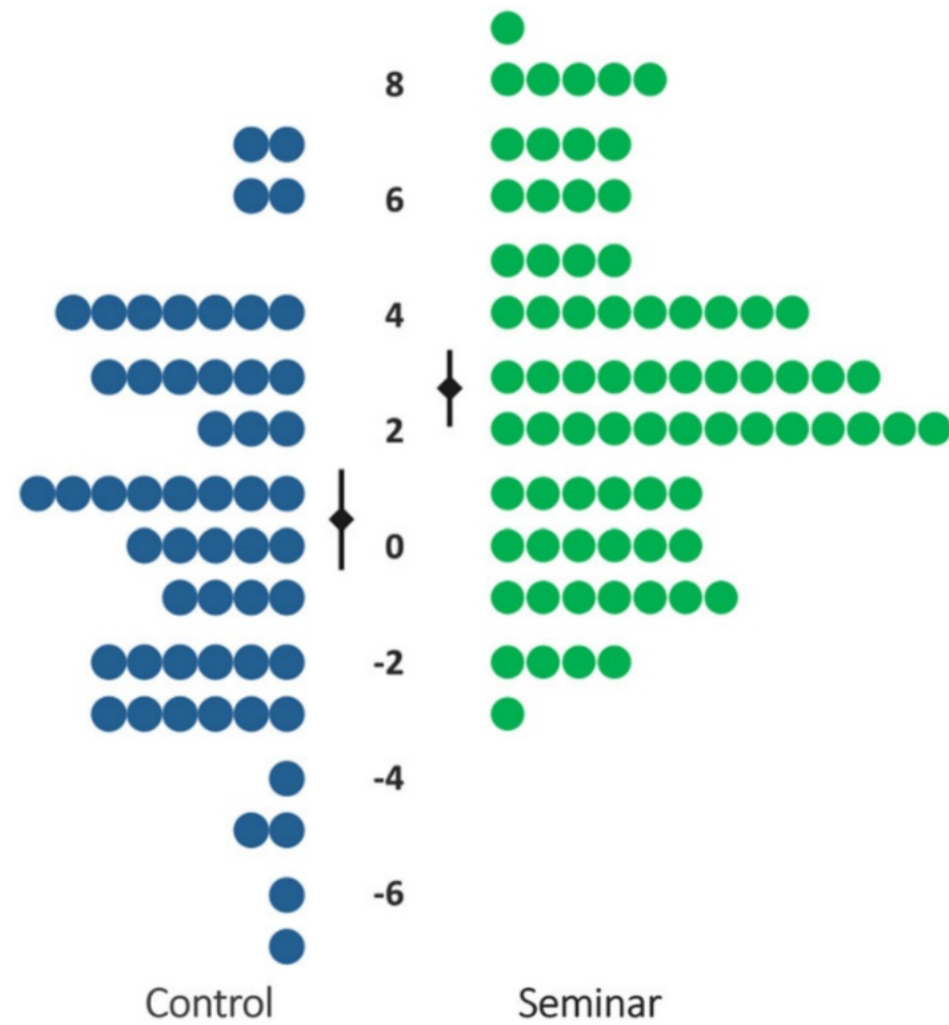


Fig. 2 Change in LSAT logical reasoning test scores in each condition with 95% confidence intervals ($p < 0.001$)

Argument visualisation improves analytical reasoning and argument understanding

Results

Participating in seminar led to improved LSAT

Seminar students had better analytical and composition skills in the context of real academic assignments

because

because

Seminar students performed better on posttest than pretest.

Control did not perform better on the posttest than they had on the pretest.

because

because

because

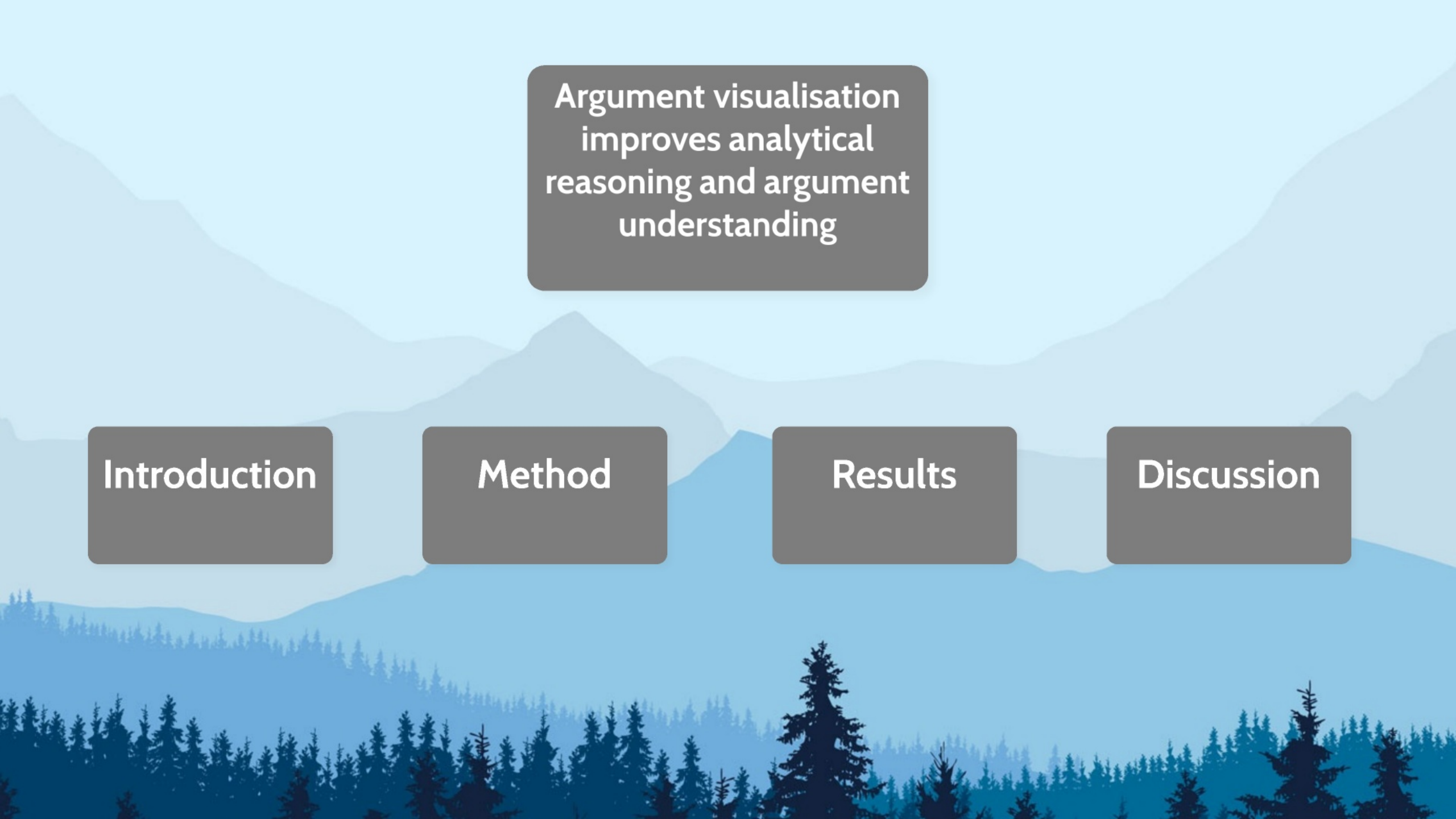
because

Seminar students structured essays more effectively

Seminar students presented arguments more accurately

Seminar students understood relevant arguments better

Seminar students received higher grades for their essays



**Argument visualisation
improves analytical
reasoning and argument
understanding**

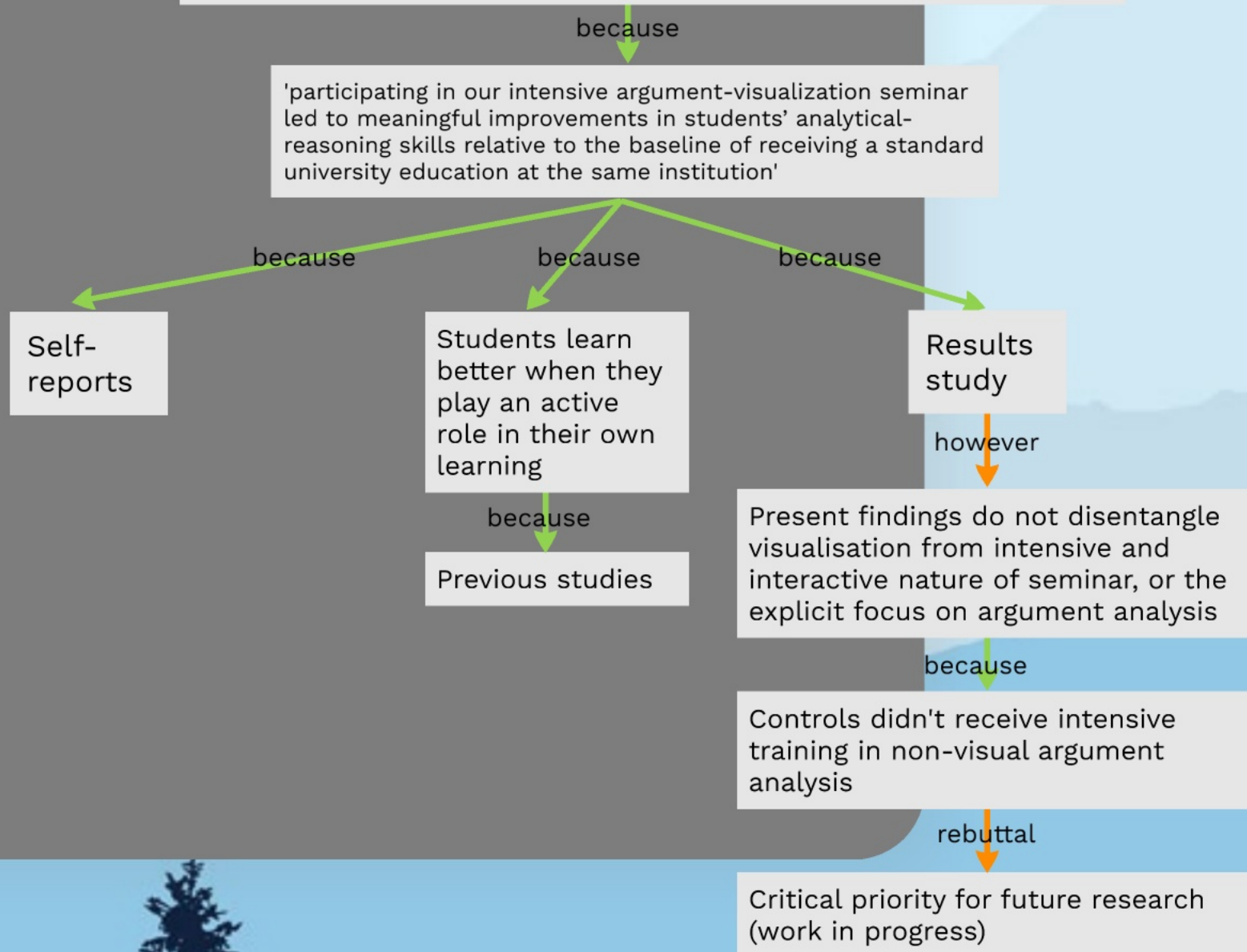
Introduction

Method

Results

Discussion

Argument visualisation improves analytical reasoning and argument understanding



Argument visualisation improves analytical reasoning and argument understanding

```
graph TD; A[Argument visualisation improves analytical reasoning and argument understanding] --> B[Student self-reports]; B --> C[Student enjoyed seminars]; B --> D[Using visualisation in other coursework]; B --> E["# students intending to do philosophy major increased by a factor of 4 in seminar group (stable in control)"]; B --> F["Strongly agreed that seminar improved ability to construct and evaluate written arguments (4.9/5)"]; B --> G["Strongly agreed that seminar improved ability to read and understand academic articles (4.9/5)"]; B --> H["Strongly agreed that new skills would help them in other coursework (4.2/5)"]; B --> I["Overall, students rated seminar 4.9/5"];
```

Student self-reports

Student enjoyed seminars

Using visualisation in other coursework

students intending to do philosophy major increased by a factor of 4 in seminar group (stable in control)

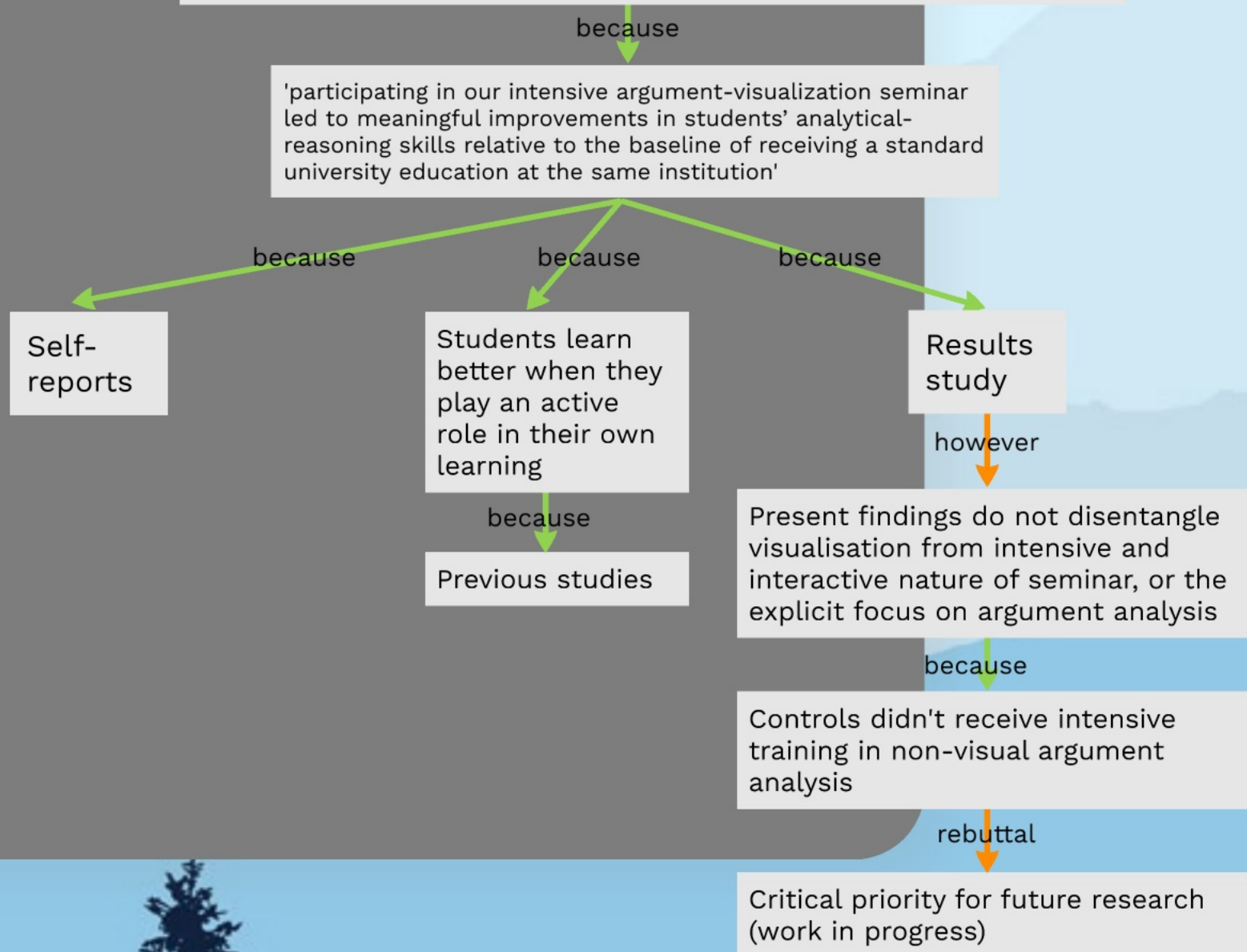
Strongly agreed that seminar improved ability to construct and evaluate written arguments (4.9/5)

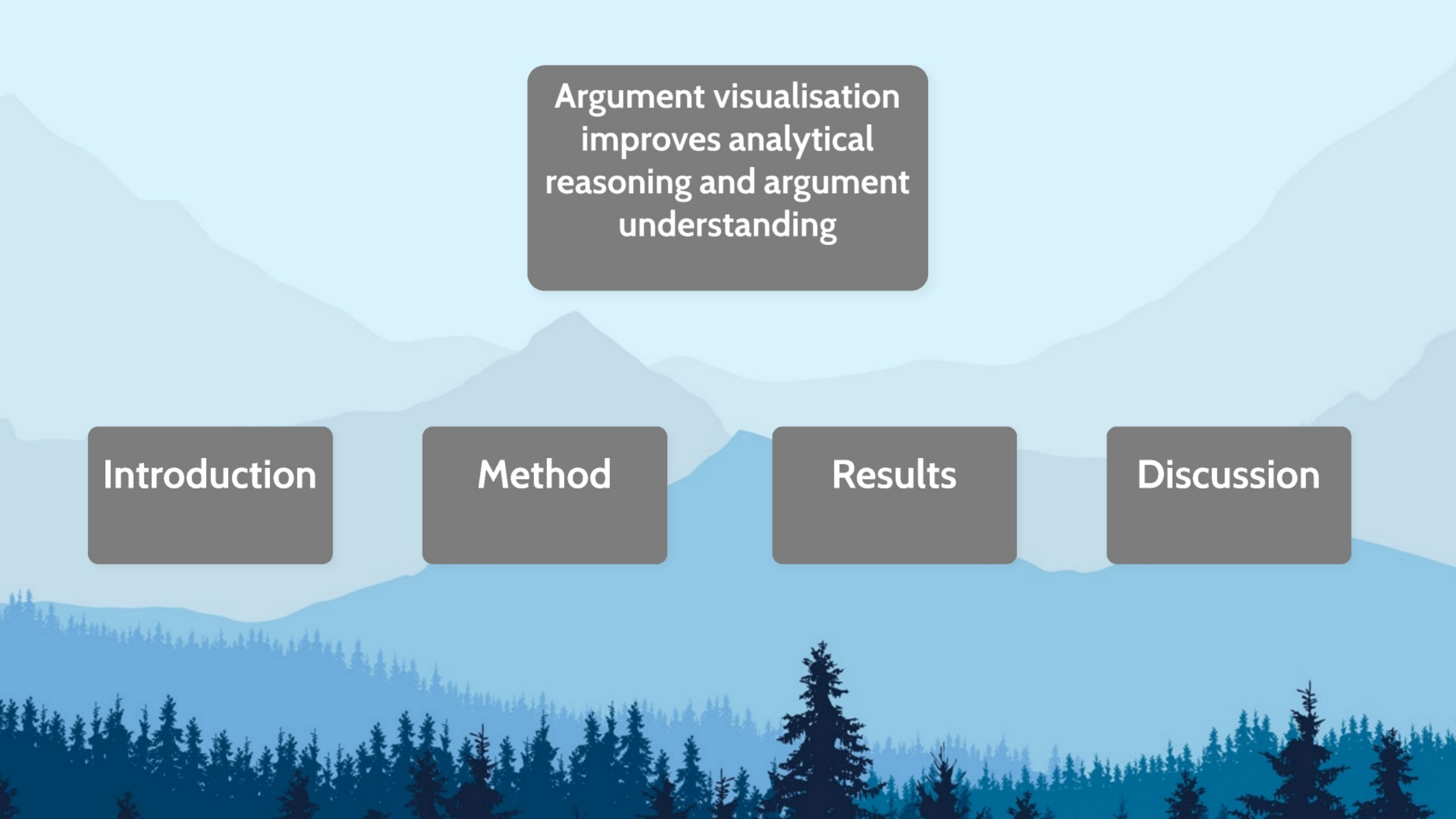
Strongly agreed that seminar improved ability to read and understand academic articles (4.9/5)

Strongly agreed that new skills would help them in other coursework (4.2/5)

Overall, students rated seminar 4.9/5

Argument visualisation improves analytical reasoning and argument understanding





**Argument visualisation
improves analytical
reasoning and argument
understanding**

Introduction

Method

Results

Discussion