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Galileo's Reconciliation of Mathematics and the Investigation of Nature

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IOWA STATE UNIVERSITY
Department of Philosophy and Religious Studies

Honors Project Poster Presentation
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Galileo's Reconciliation of Mathematics and the Investigation of Nature

Objective

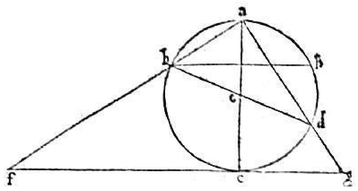
In modern science, mathematics is an essential element of the process of gaining knowledge of nature. However, this was not the case during the early modern period (the sixteenth through eighteenth centuries). This project explores Galileo's impact on the use of mathematics in the investigation of nature.

The Practical Problem

Observed values in nature do not exactly match mathematically predicted ones, making mathematics inappropriate for the investigation of nature.

Why is this a problem?

- Natural philosophers required certainty in descriptions of nature
- Observations of mathematical quantities do not match over multiple trials
- Mathematically calculated predictions do not match observed values
- Therefore, mathematics does not provide certain knowledge of nature



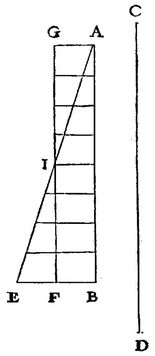
Why did this matter to Galileo?

- Galileo used mathematical calculations to make statements about nature
- His calculations could not be applied to nature without solving the problem
- He recognized the Practical Problem in the *Dialogue*:

Mathematicians may prove well enough in theory that sphaera tangit planum in puncto [the sphere touches the plane at one point] . . . but when it comes to matter, things happen otherwise - Galilei, Dialogue p. 231

The Ontological Problem

Mathematics is not appropriate for generating knowledge about nature because nature does not have essential mathematical properties.



Why is this a problem?

- The investigation of nature values qualitative over quantitative descriptions.
- Mathematics applies only to quantities, not essential qualities.
- Natural Philosophers looked only for universal qualities, not specific quantities.
- Therefore, mathematics is not applicable to generating knowledge about nature.

Why did this matter for Galileo?

- Galileo was interested in generating knowledge about nature
- His primary method for generating knowledge was through mathematics
- He recognized the Ontological Problem:

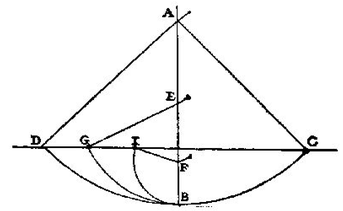
Philosophers occupy themselves principally about universals . . . leaving the mathematicians certain fragments and subtleties, which are then rather curiosities. Galilei, Dialogue p. 190

Galileo's Solution to the Practical Problem

Recognize accidental impediments and analyze their effect in relation to predicted values.

How does he solve the problem?

- Observations were seen as describing the essence of things
- Galileo recognized accidental impediments in observations of nature
- He quantifies the effect of impediments in observations
- If the effects are small enough, then mathematical propositions apply



What's an example of his solution?

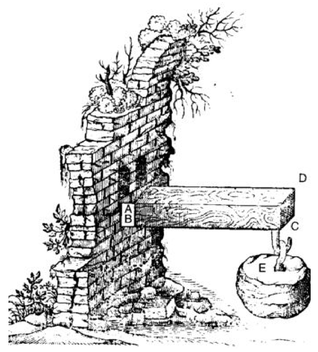
- In observations of new stars, Galileo recognizes impediments:

  whenever the calculations made from the observations of these astronomers do not agree in putting it in the same place, there must be errors in the observations. Galileo, Discourses p. 336

- In analysis of pendulums, Galileo determines error is insignificant to the calculation

Galileo's Solution to the Ontological Problem

Value mathematical reasoning over qualitative observation.



How does he solve the problem?

- Galileo views mathematical entities as universal intelligibles
- The mathematical intelligibles provide certain knowledge about nature
- Reasoning from basic intelligibles results in rules that constrain observations
- Since mathematical rules constrain nature, they provide certain knowledge

What's an example?

- Materials don't scale up the same as mathematical entities do:

  one cannot reason from the small to the large, because many mechanical devices succeed on a small scale that cannot exist in great size. Galilei, Discourses p. 12

- Reasoning from mathematical rules one concludes that surface area does not scale with volume and that one can derive a mathematical rule for the strength of materials:

  all geometrically demonstrated … in such a way that not without reason this could be called a new science. Galilei, Discourses p. 13

Conclusions

Galileo's solutions to the Practical and Ontological Problems allowed him to generate knowledge about nature using mathematics. This means that his investigation of nature in the *Dialogue* and *Discourses* generated certain knowledge of nature necessary for scientific progress.

References

Galilei, G. *Dialogue on the Two Chief World Systems*. 1632. Drake, S. (tr), 1953.
Galilei, G. *Discourses on Two New Sciences*. 1638. Drake, S. (tr), 1974.