

Mathematical Complexity of Computational Modeling Experiences for Elementary Students

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SRI Education







Curricular context: Modeling urban water runoff

- Multi-week, 5th grade curriculum unit integrating earth science, engineering, and computational thinking (NGSS PEs 5-ESS3-1, 3-5ETS1-3)
- Students develop a computational model of water runoff and use it to test and refine engineering solutions



Designing the runoff model



Basic runoff system model



- set StormDuration to...
- set ElapsedTime to 0
- set HourlyRainfall to...
- set TotalAbsorption to 0
- set TotalRunoff to 0
- set TotalRainfall to 0
- set AbsorptionCoeff to....

variable initialization

simulation with stopping condition

Repeat until (ElapsedTime is equal to StormDuration)
 change ElapsedTime by 1
 change TotalRainfall by HourlyRainfall
 change TotalAbsorption by ...
 set TotalRunoff to TotalRainfall – TotalAbsorption

- set StormDuration to...
- set ElapsedTime to 0
- set HourlyRainfall to...
- set TotalAbsorption to 0
- set TotalRunoff to 0
- set TotalRainfall to 0
- set AbsorptionCoeff to...

Temporal variables require reasoning about rates and durations

Repeat until (ElapsedTime is equal to StormDuration)
 change ElapsedTime by 1
 change TotalRainfall by HourlyRainfall
 change TotalAbsorption by ...
 set TotalRunoff to TotalRainfall – TotalAbsorption

- set StormDuration to...
- set ElapsedTime to 0
- set HourlyRainfall to...
- set TotalAbsorption to 0
- set TotalRunoff to 0
- set TotalRainfall to 0
- set AbsorptionCoeff to...

Hourly vs. total variables

Repeat until (ElapsedTime is equal to StormDuration)
 change ElapsedTime by 1
 change TotalRainfall by HourlyRainfall
 change TotalAbsorption by ...
 set TotalRunoff to TotalRainfall – TotalAbsorption

- set StormDuration to...
- set ElapsedTime to 0
- set HourlyRainfall to...
- set TotalAbsorption to 0
- set TotalRunoff to 0
- set TotalRainfall to 0
- set AbsorptionCoeff to...

Repeat until (ElapsedTime is equal to StormDuration)
 change ElapsedTime by 1
 change TotalRainfall by HourlyRainfall
 change TotalAbsorption by ...
 set TotalRunoff to TotalRainfall – TotalAbsorption

"set" vs. "change"

- set StormDuration to...
- set ElapsedTime to 0
- set HourlyRainfall to...
- set TotalAbsorption to 0
- set TotalRunoff to 0
- set TotalRainfall to 0
- set AbsorptionCoeff to...

Repeat until (stopping condition) is challenging

Repeat until (ElapsedTime is equal to StormDuration)

change ElapsedTime by 1
change TotalRainfall by HourlyRainfall
change TotalAbsorption by ...
set TotalRunoff to TotalRainfall - TotalAbsorption

- set TotalRainfall to...
- set AbsorptionLimit to...
- if (TotalRainfall is equal to AbsorptionLimit)
 set TotalAbsorption to TotalRainfall
 set TotalRunoff to 0
- if (TotalRainfall is less than AbsorptionLimit)
 set TotalAbsorption to TotalRainfall
 set TotalRunoff to 0
- if (TotalRainfall is greater than AbsorptionLimit)
 set TotalAbsorption to AbsorptionLimit
 set TotalRunoff to TotalRainfall TotalAbsorption

- set TotalRainfall to...
- set AbsorptionLimit to...

No rate-based or temporal variables

- if (TotalRainfall is equal to AbsorptionLimit)
 set TotalAbsorption to TotalRainfall
 set TotalRunoff to 0
- if (TotalRainfall is less than AbsorptionLimit)
 set TotalAbsorption to TotalRainfall
 set TotalRunoff to 0
- if (TotalRainfall is greater than AbsorptionLimit)
 set TotalAbsorption to AbsorptionLimit
 set TotalRunoff to TotalRainfall TotalAbsorption

- set TotalRainfall to...
- set AbsorptionLimit to...

No "change"

- if (TotalRainfall is equal to AbsorptionLimit)
 set TotalAbsorption to TotalRainfall
 set TotalRunoff to 0
- if (TotalRainfall is less than AbsorptionLimit)
 set TotalAbsorption to TotalRainfall
 set TotalRunoff to 0
- if (TotalRainfall is greater than AbsorptionLimit)
 set TotalAbsorption to AbsorptionLimit
 set TotalRunoff to TotalRainfall TotalAbsorption

- set TotalRainfall to...
- set AbsorptionLimit to...

Simpler conditions; no nesting

- if (TotalRainfall is equal to AbsorptionLimit)
 set TotalAbsorption to TotalRainfall
 set TotalRunoff to 0
- if (TotalRainfall is less than AbsorptionLimit)
 set TotalAbsorption to TotalRainfall
 set TotalRunoff to 0
- if (TotalRainfall is greater than AbsorptionLimit)
 set TotalAbsorption to AbsorptionLimit
 set TotalRunoff to TotalRainfall TotalAbsorption

Designing the runoff model



Designing the runoff model



Summary

- Computational modeling experiences are constrained by grade-appropriate mathematics concepts, especially in elementary
- Designers may be challenged to align multiple educational frameworks (NGSS, CS Framework, CCSSM) at specific grade levels
- Argues for a broad definition of "computational model" for STEM+C education
 - model that leverages computational affordances (e.g., facilitates rapid testing and iterative refinement)

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Acknowledgements: This material is based upon work supported by the National Science Foundation under Grant No. DRL-1742195. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

