A System Dynamics Approach to Inform Decision-Making in STEM Education

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WPI STEM Education Center

The Motivation/Problem

The need: Effective implementation of STEM initiatives in order to attract and prepare students to enter college STEM programs and, ultimately, the STEM workforce

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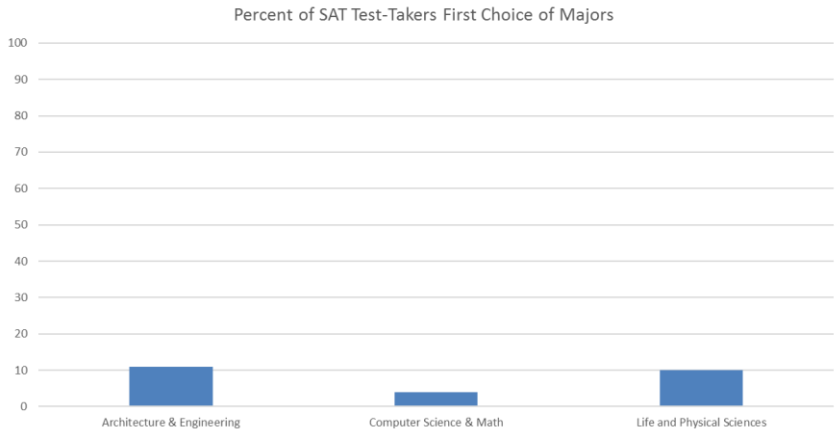
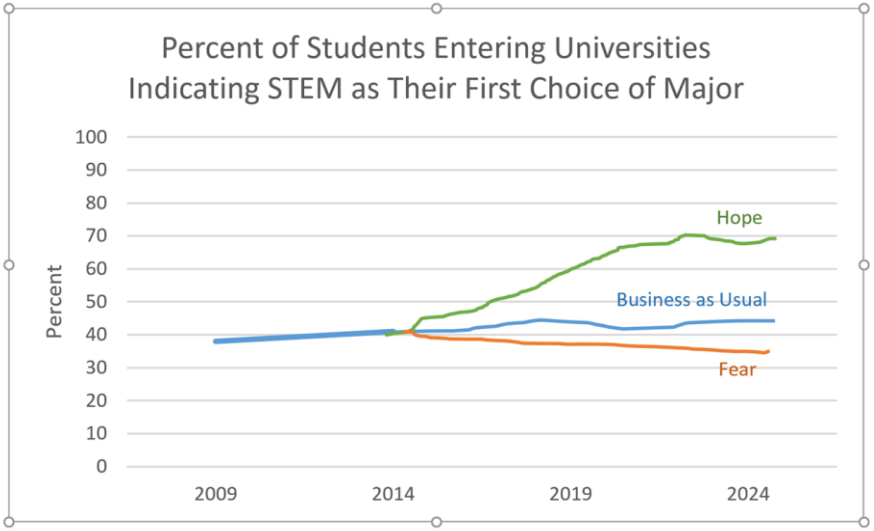
Background

- College-bound graduates enroll in a post-secondary STEM program: 41%.
- 10 year STEM workforce projected growth: 11.2%
- Projected annual openings: 47,335 positions each year





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Research Questions

Question 1: What are the variables that determine the impact of teacher and district STEM capacity on the number of students entering college STEM programs

Question 2: To what extent can system dynamics models of STEM education systems be predictive of success in STEM improvement efforts?

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Methodology

- A System Dynamics model was developed using average state data to generalize district system components that impact the effectiveness of STEM integration
  - The primary objective is to increase the number of high school students who pursue STEM education in a higher education institution.
  - Supporting objectives include:
    - increasing teacher efficacy in teaching STEM
    - Increasing student efficacy in learning STEM.
- System Dynamics modeling techniques will be used to help education leaders understand their system in order to make better policy implementation decisions.

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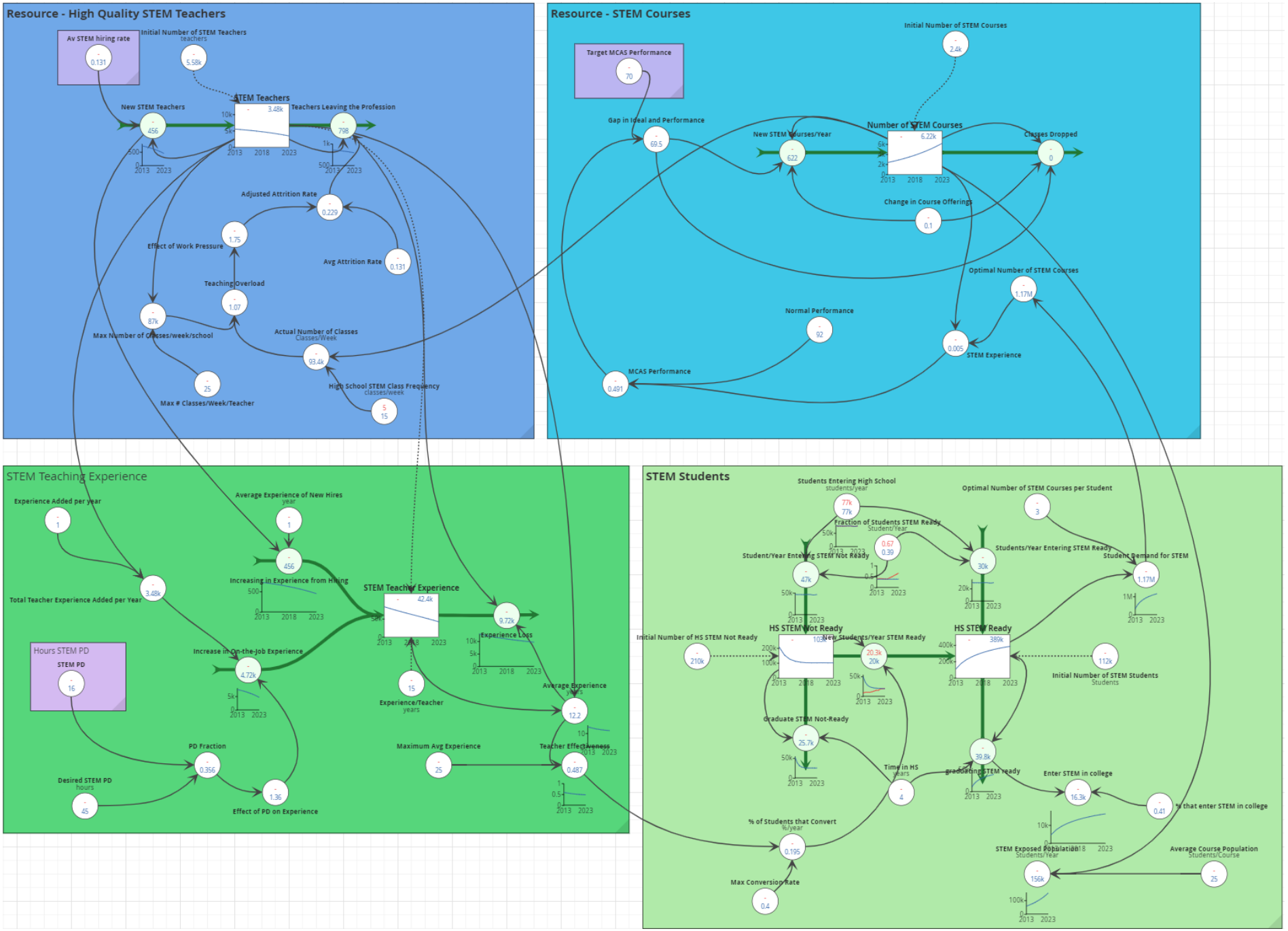
Students' Choice to Study STEM

- Factors that impact student choice
  - Experience
  - Capacity
  - Interest

- Variables that Influence Factors
  - Number of STEM Teachers
  - STEM Teacher Efficacy
  - Number of STEM Courses


Resource - High Quality STEM Teachers
Av STEM hiring rate
0.131
Initial Number of STEM Teachers
teachers
5.58k
STEM Teachers
3.48k
New STEM Teachers
456
Teachers Leaving the Profession
798
Adjusted Attrition Rate
0.229
Effect of Work Pressure
1.75
Avg Attrition Rate
0.131
Teaching Overload
1.07
87k
Max Number of Classes/week/school
Actual Number of Classes
Classes/Week
93.4k
25
Max # Classes/Week/Teacher
High School STEM Class Frequency
classes/week
5
15
Resource - STEM Courses
Target MCAS Performance
70
Initial Number of STEM Courses
2.4k
Gap in Ideal and Performance
69.5
New STEM Courses/Year
622
Number of STEM Courses
6.22k
Classes Dropped
0
Change in Course Offerings
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Optimal Number of STEM Courses
1.17M
Normal Performance
92
0.005
STEM Experience
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0.491
STEM Teaching Experience
Experience Added per year
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Average Experience of New Hires
year
1
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Increasing in Experience from Hiring
Total Teacher Experience Added per Year
3.48k
STEM Teaching Experience
42.4k
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Experience Loss
Hours STEM PD
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16
Increase in On-the-Job Experience
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Experience/Teacher
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PD Fraction
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STEM Students
Students Entering High School
students/year
77k
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Fraction of Students STEM Ready
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Student/Year Entering STEM Not Ready
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Student Demand for STEM
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210k
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New Students/Year STEM Ready
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389k
112k
Initial Number of STEM Students
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Graduate STEM Not-Ready
25.7k
Time in HS
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graduating STEM ready
Enter STEM in college
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% that enter STEM in college
% of Students that Convert
%/year
0.195
Max Conversion Rate
0.4
STEM Exposed Population
Students/Year
Average Course Population
Students/Course
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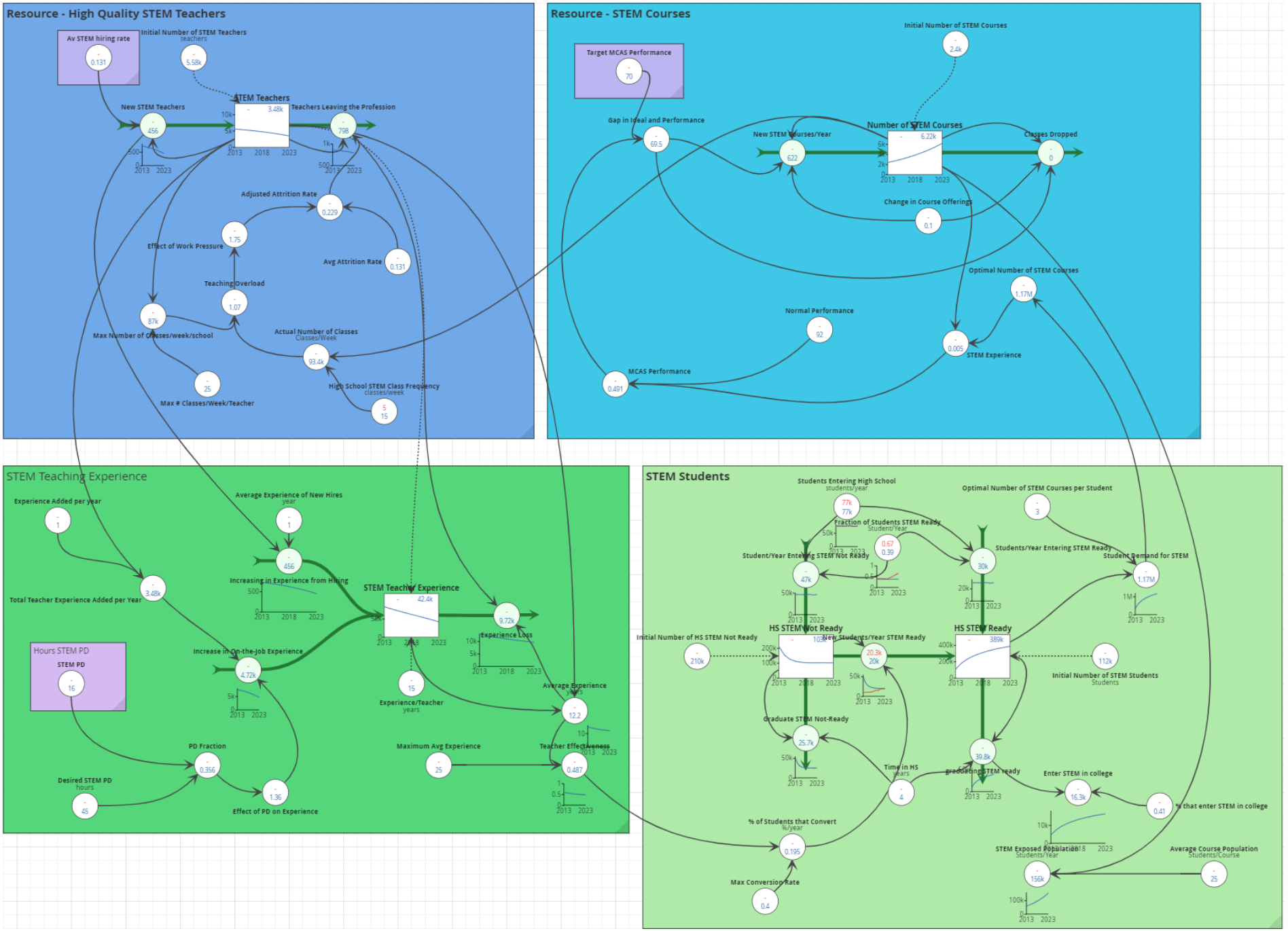
Teacher Development

- Efficacy in teaching STEM (Capacity + Agency)
  - Teaching load
  - Teaching skills
  - Teaching experience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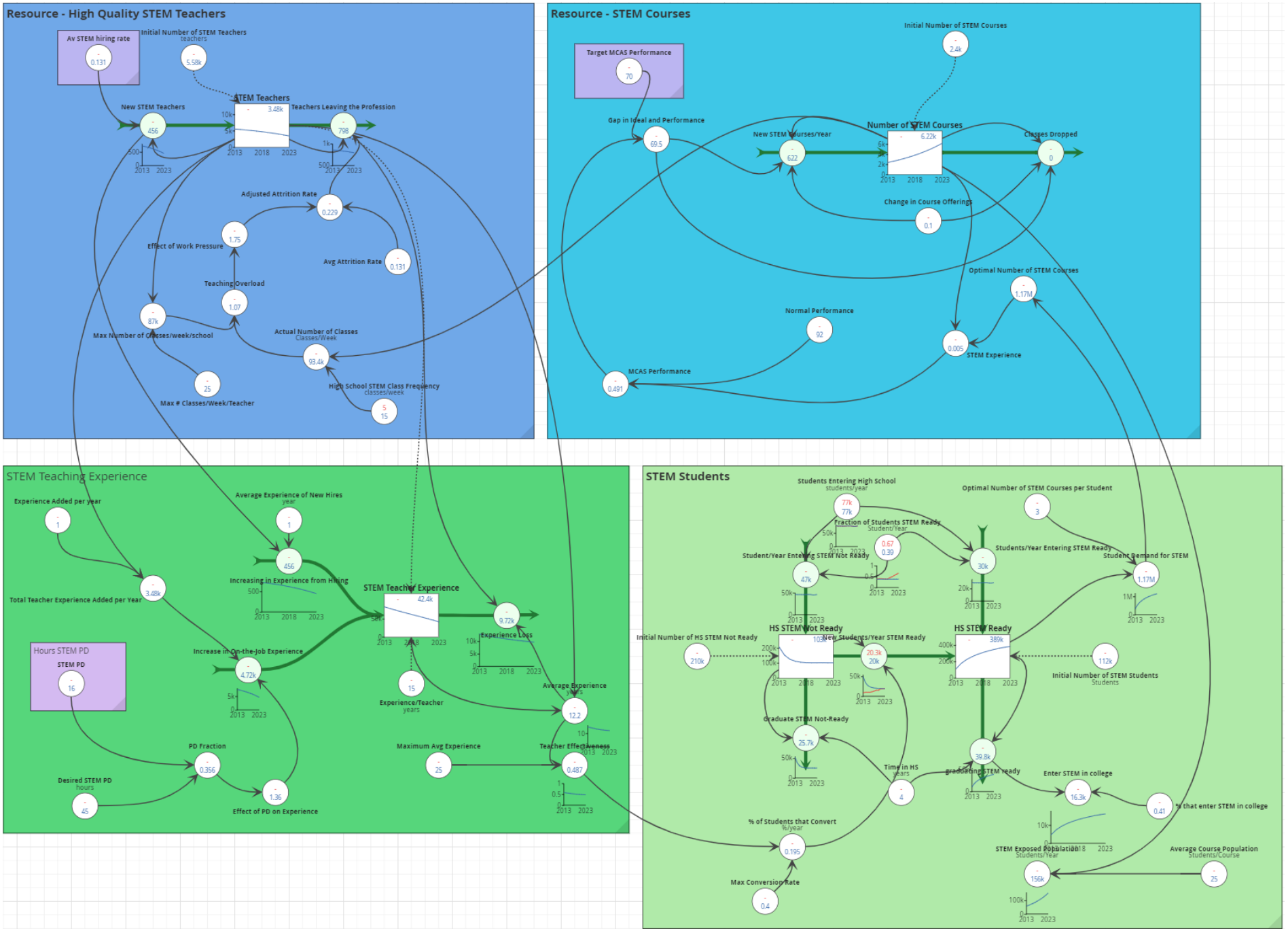
Administrative Decision Levels

Three decision points were included in the model to represent decisions school administrators can make to leverage change when implementing district policy decisions.

1. Number of STEM Teachers
   - Hiring rate
2. STEM Teacher Development
   - Years of Experience + Professional Development
3. MCAS Performance Goal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Implications/Future Work

- Model validation
- Integration of Service Science and System Dynamics
  - Service Science Canvas
    - Static data to inform the dynamic model
    - Apply to 4 identified schools with varying success in STEM integration
- Education Leaders Professional Development Workshops
  - Structured protocol to elicit mental models based on the service science canvas
  - Group model building with districts to reflect the dynamic nature of their school system
  - Guided strategic decision making to improve STEM integration implementation