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Recommendation to Implement A New BPS Assignment Algorithm

Boston School Committee
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BPS Strategic Planning Team
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I. Why Evaluate the Boston Mechanism?

- This is one part of a larger review to achieve a higher level of parental satisfaction and transparency in the outcomes of the student assignment process.
- In response to work done by a team of Economic Engineers on student matching mechanisms:
  - Atila Abdulkadiroğlu, Ph.D., Professor, Columbia University
  - Parag A. Pathak, Ph.D. Candidate, Harvard University
  - Alvin E. Roth, Ph.D., Professor, Harvard University
  - Tayfun Sönmez, Ph.D., Professor, Koç and Harvard Universities
- BPS staff was convinced strategizing was likely occurring, to the detriment of students and families, during an October 2003 meeting with the economists.

II. October 2004 "Algorithm 101" Presentation to School Committee

- What is an Algorithm?
- Key Components of BPS Assignment Mechanism
  - Priorities
  - Preferences
  - Random Numbers
- Sample Case Study: Estella's Assignment
- Issues With the Current BPS System
- Two Alternate Mechanisms

What Is an Algorithm?

An algorithm is "a set of ordered steps for *SOLVING A PROBLEM*, such as a mathematical formula or the instructions in a program."

— *Computer Desktop Encyclopedia, © 1988-2004, Computer Language Company, Inc.*

- In our case, the *problem* is to assign students to schools, while:
  - Respecting each student's PREFERENCES
  - Adhering to each school's PRIORITIES
  - Making sure that each school is filled to its proper capacity

- Our *solution*: The Boston Assignment Mechanism -- the computer program that actually implements assignment policy.

Key Components of Boston Mechanism

- Families have PREFERENCES for schools and make CHOICES
  - Families HAVE CONTROL over their choices
- PRIORITIES order who gets assigned to each school
  - PRIORITIES are based on home address and sibling status
  - Families CANNOT control their priorities
  - BPS' PRIORITY categories are:
    1. SIBLING / WALK
    2. SIBLING / NON-WALK
    3. WALK
    4. NO PRIORITY

Here are the schools that Estella really wants:

1st choice:	Murphy
2nd choice:	Channing
3rd choice:	Perkins

Estella

Estella's True Preferences

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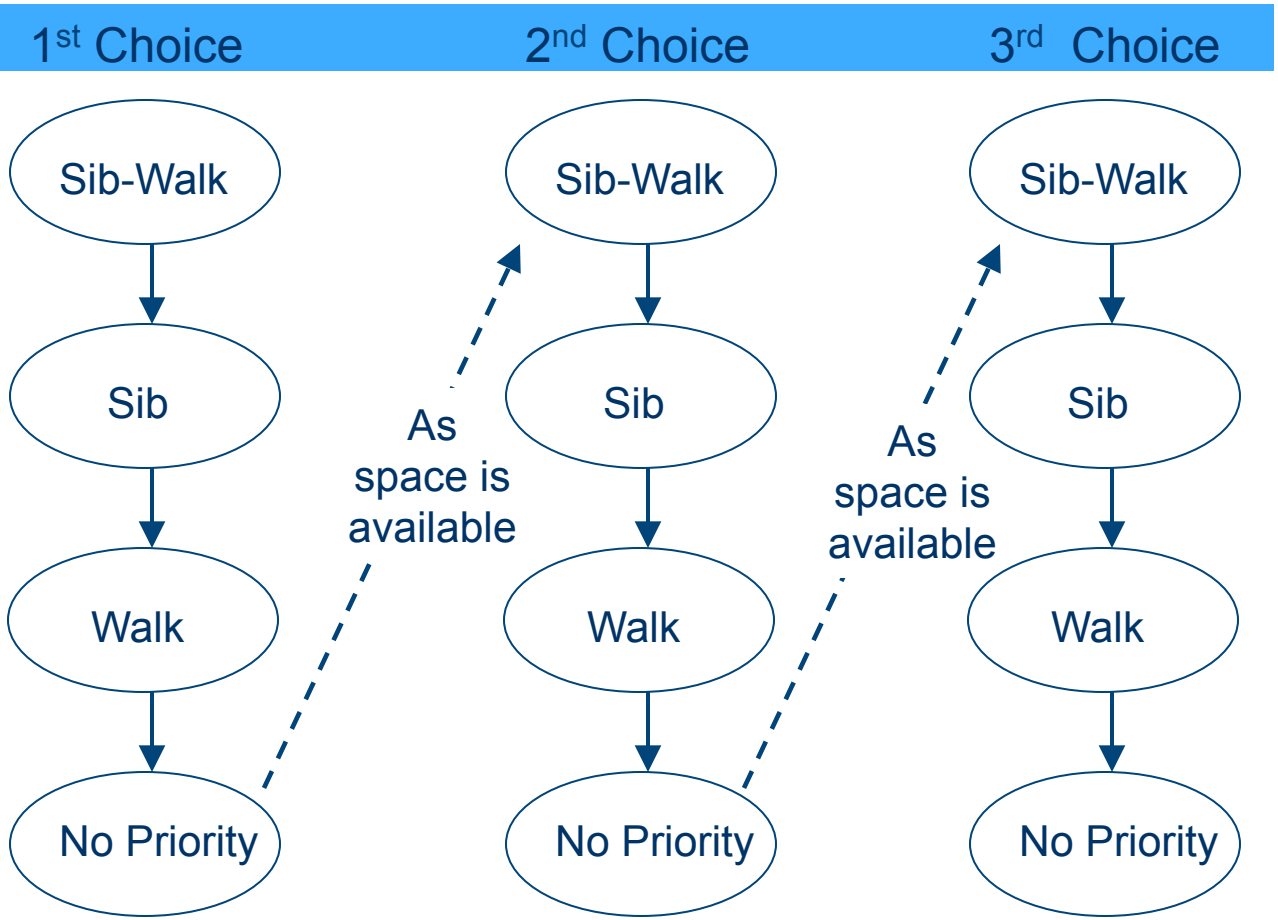
Here are the PRIORITIES Estella has at each school:

	CHOICE	SIBLING	WALK	RANDOM#
MURPHY	1	NO	NO	5
CHANNING	2	YES	NO	5
PERKINS	3	NO	YES	5

Estella's Priorities

How the BPS Currently Assigns Students

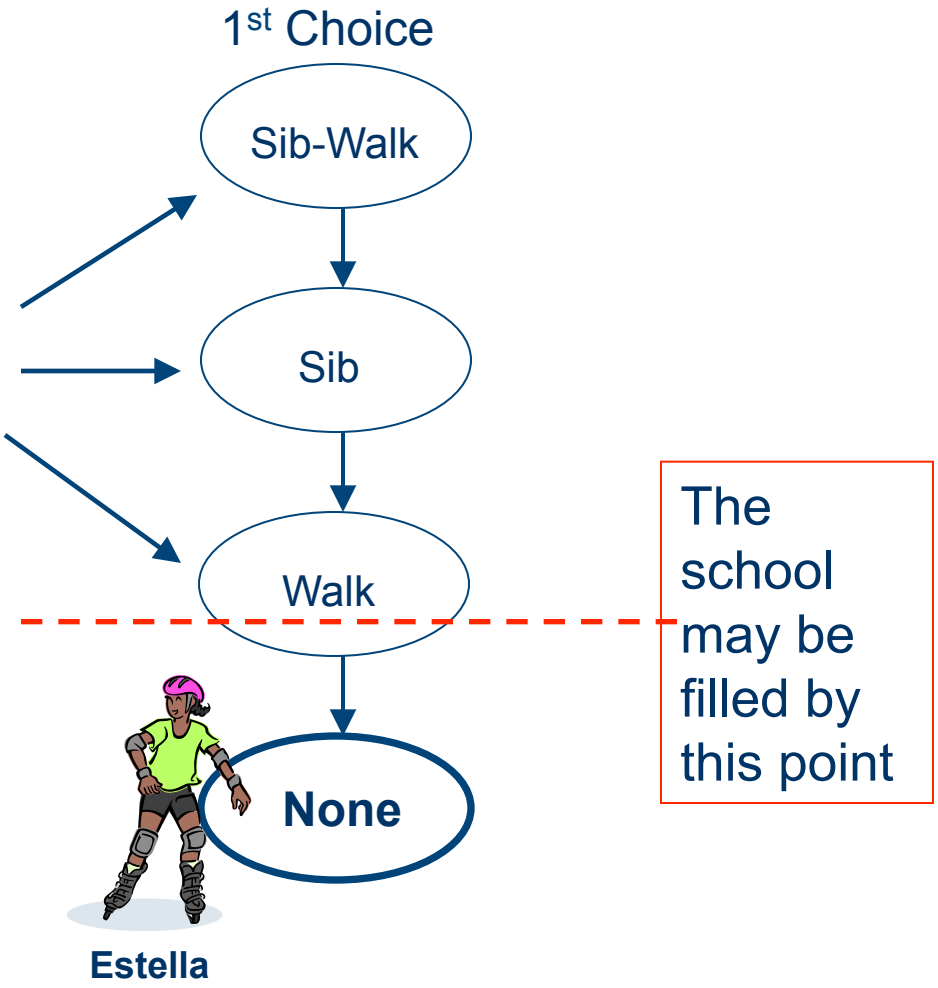


Within each category, students are ordered by their random numbers

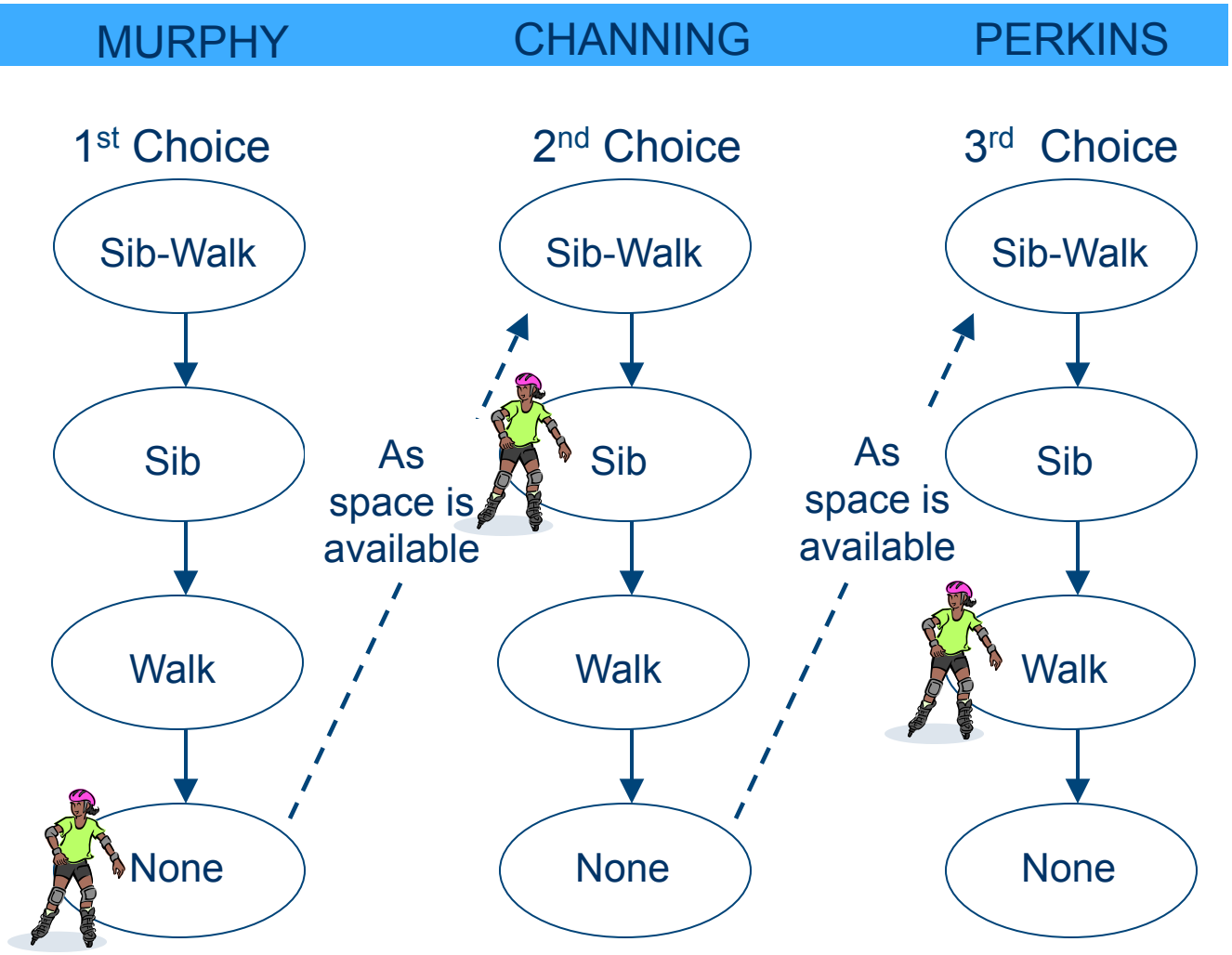
Where Estella's Priorities Position Her for the MURPHY K-8 School

Students in 3 priority categories are ahead of Estella

Seats will be filled by students in 3 categories before reaching Estella



How it Looks for Estella at Each School



Estella's Perceived Chances

Here is what Estella's family believes are her chances of getting each school if they make it their first choice:

	Chance	Because?
Channing	Best chance	**Sibling priority. Medium Popularity.**
Perkins	Good chance	**They live in the walk zone. Not Very Popular.**
Murphy	Worst chance	**They have no priority. Very Popular.**

Estella's Family Strategizes

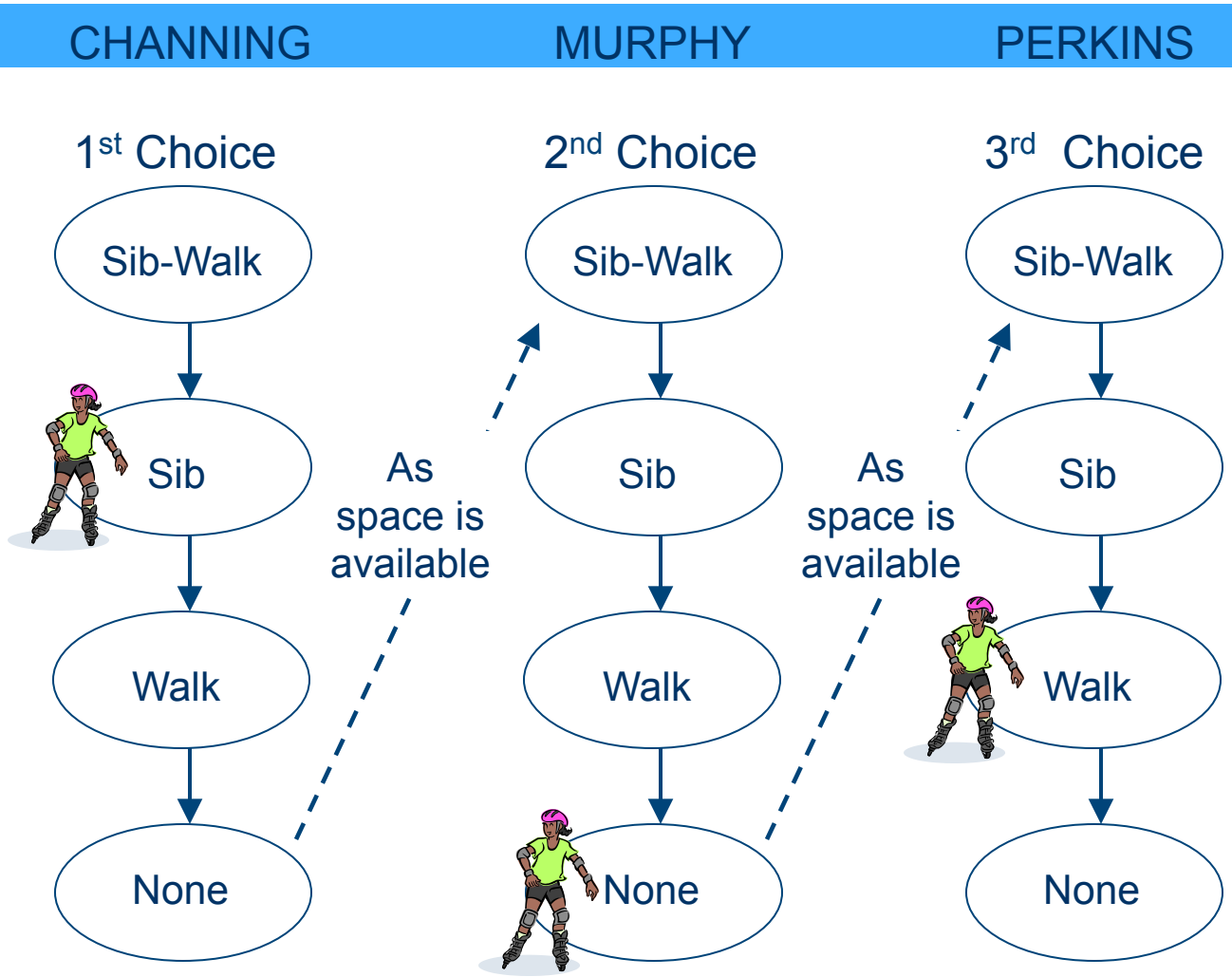
Here is how Estella's family ***reorders their choices*** to ensure the best outcome given Estella's preferences and priorities:

1st choice:	~~Murphy~~ **Channing**
2nd choice:	~~Channing~~ **Murphy**
3rd choice:	**Perkins**

The Problems With the BPS System

- The current process forces families to STRATEGIZE.
- Strategizing is imperfect because families don't know:
  - what their random number will be.
  - what schools other families are choosing.
  - how many others they're competing with.
- Assignment becomes a high-stakes gamble for families.
- Undermines families' trust in the BPS system.
- Families should not have to sacrifice their true preferences.
- Families should be able to be forthright about their choices.
- The system, not families, should compensate for mismatches between preferences and priorities.

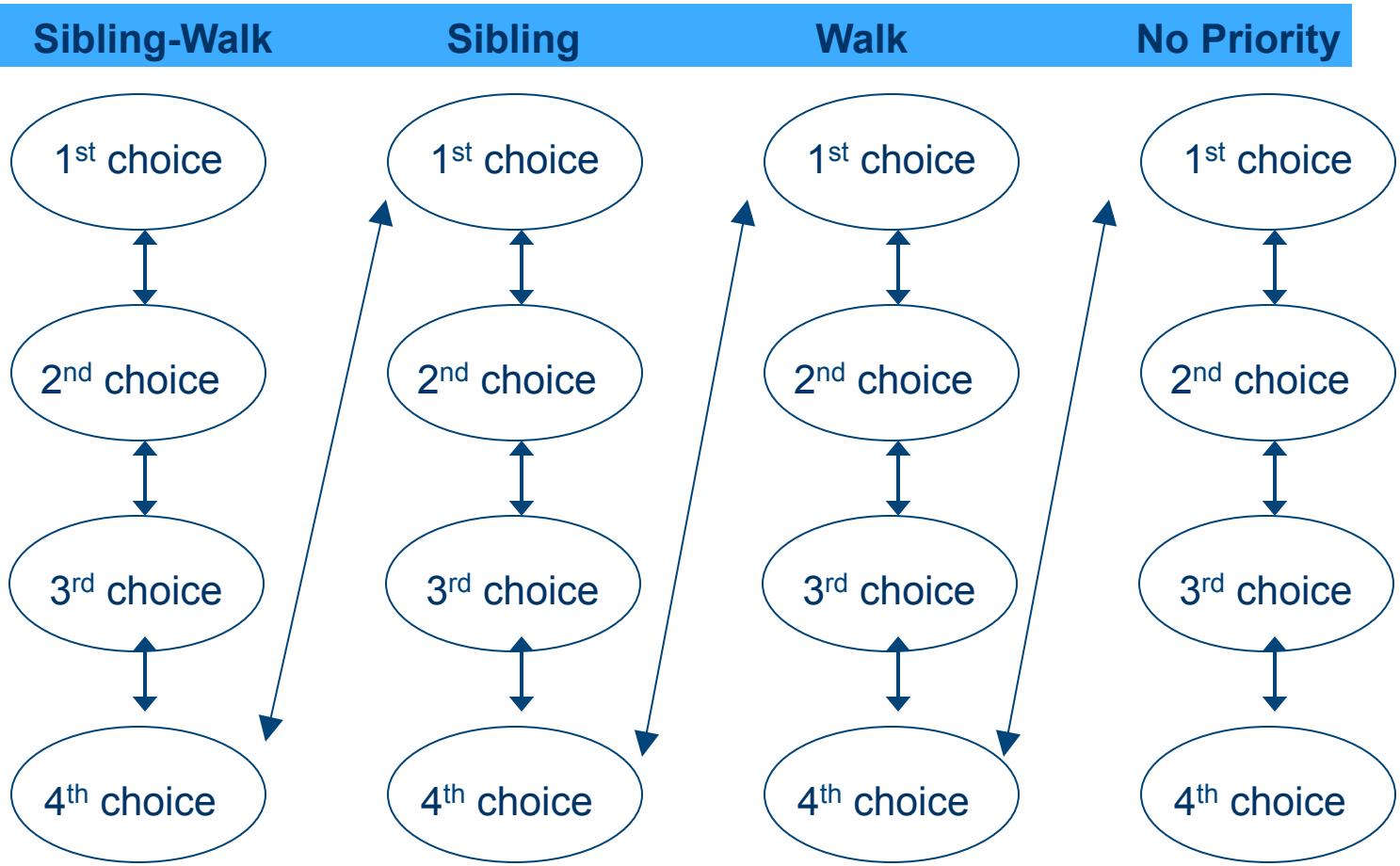
How It Looks Now for Estella at Each School



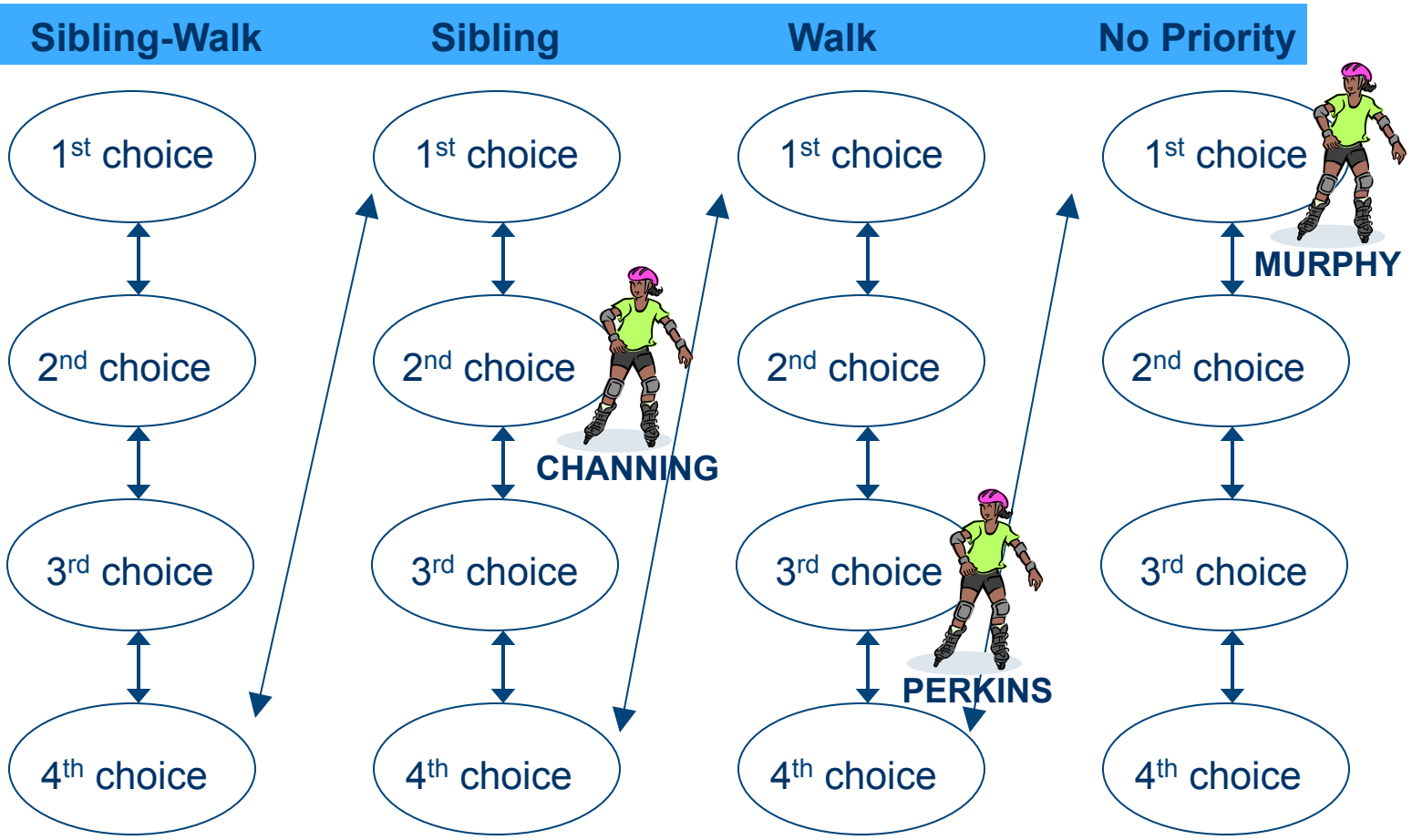
Alternatives to Current Mechanism

- Two alternatives that eliminate the need for strategizing are:
  - ***The Gale -Shapley Deferred Acceptance Mechanism***
  - ***The Top-Trading Cycles Mechanism***
- The BPS has been working with a team of economists who are experts on these alternatives
- These economists are helping the BPS explore the potential benefits of switching to one of these alternatives

The Gale-Shapley Method



Estella With Gale-Shapley Method



Gale-Shapley Method

- Orders students by priorities and by choices, without discarding ANY choices or priorities
- Uses ITERATIVE method - searches back and forth to put each student into TOP-MOST choice without sacrificing the priorities of other students
- Allows students to choose their True Preferences without potentially being penalized by selecting a highly chosen school as their first choice

Gale-Shapley Method Pros & Cons

PRO:	CON:
• Considers all priorities and preferences throughout the whole assignment process	• Considers priorities more strongly than 1st choices
• Eliminates the need for families to strategize	• Is not focused on providing the highest percentage of 1st choices

Estella With Top Trading Cycles Method

Estella has a priority to the CHANNING, which Frank wants, and Frank has a priority to the MURPHY, which Estella wants, so the system lets them TRADE. Now each gets a seat at their 1st choice school

Estella

CHANNING

PERKINS

MURPHY (1st)

Priorities & Positions Will Be Traded

Frank

MURPHY

CHANNING (1st)

PERKINS

Top Trading Cycles

- Starts with the highest priority students at the schools. Students either keep the seat if it's at their top choice school, or trade it.

- Students who want to trade priorities are allowed to do so. This means that, when two students want schools that the other has the higher priority for, they can trade their priorities with each other in exchange for a seat in each other's schools.

- Allows students to choose their True Preferences without potentially being penalized by selecting a highly chosen school as their first choice.

Top Trading Cycles Pros & Cons

PRO:

- Allows students to trade priorities for top choice seats
- Eliminates the need for families to strategize

CON:

- Can have the effect of "diluting" priorities' impacts, if priorities are to be "owned" by the district, as opposed to being "owned" by parents
- Could lead to families believing they can strategize by listing a school they don't want in hopes of a trade.

Comparison Between BPS, G-S and TTC

	Rewards Strate-gizing?	Holds 'Place in Line' ?	Strongest Driver:	Rewards True Choices?
BPS	YES	NO	FIRST CHOICE	NOT ALWAYS
Gale-Shapley	NO	YES	PRIORITIES; ANY CHOICE	YES
Top Trading Cycles	NO	YES	TOP CHOICES; TRADING	YES

III. Report on Preliminary Findings of BPS Choice Data Study

- In April 2005, our team of economists presented a preliminary report of findings from their study of the potential impact of changing the BPS student assignment algorithm from a priority matching algorithm to one of the two proposed strategy-proof algorithms.
- The economists ran the three algorithms, based on the actual school choices made by BPS parents from 1999-2003

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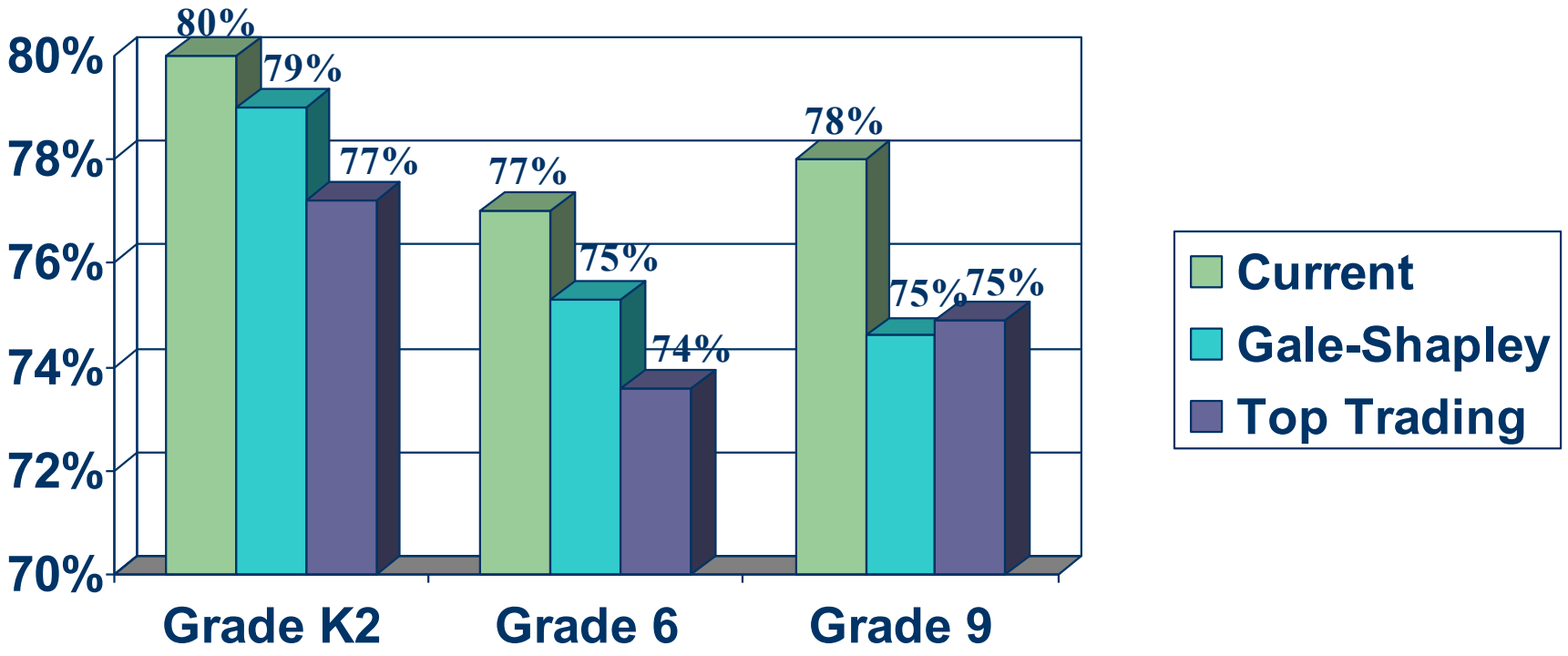
Summary Of Key Findings

1. The analysis of choice data from SY1999-2003 indicated that:
   - Many families *take the risk* of choosing an over-demanded school into account when making school selections.
   - Many families mitigate that risk by selecting a *"safety" school* as their second choice.
   - Many families who do not adequately take this risk into account receive *worse assignments* than they otherwise could have.
2. The adoption of a strategy-proof algorithm, when holding current choice patterns constant, does not significantly change the outcome of the assignment process while removing the risk of ranking schools in simple order of preference.
3. Adopting a strategy-proof algorithm would:
   - Eliminate the need for parents to "strategize" in ranking school preferences -- allowing parents to rank schools in order of true preferences without having to consider the popularity of the desired school
   - Diminish the harm done to parents who do not strategize or do so well.

Under Each Algorithm, Still 74% or Higher of Students Receive Their First Choice School

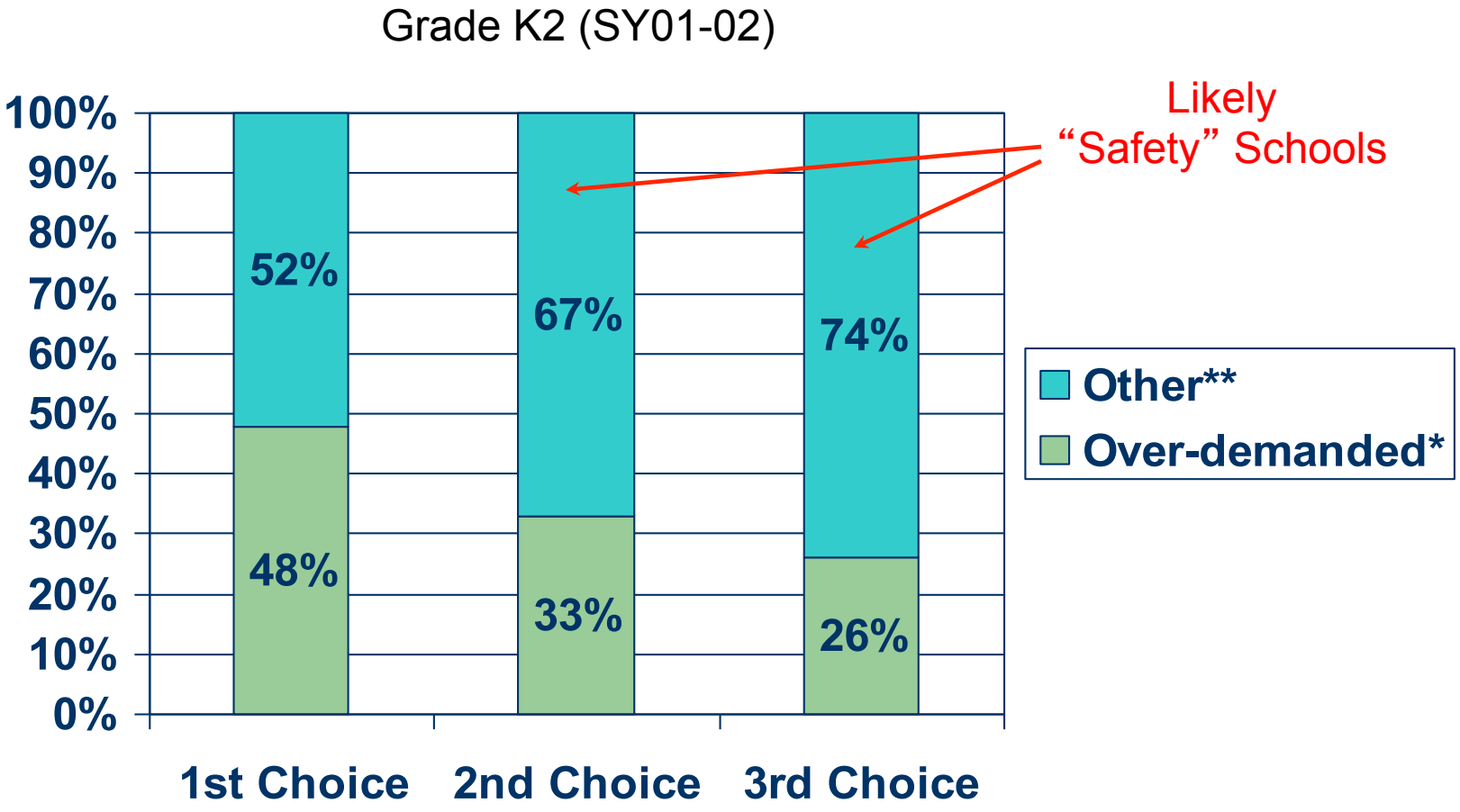
Using Actual BPS Choices (SY01-02)



So Why Change?
A Comparison of the Three Algorithms

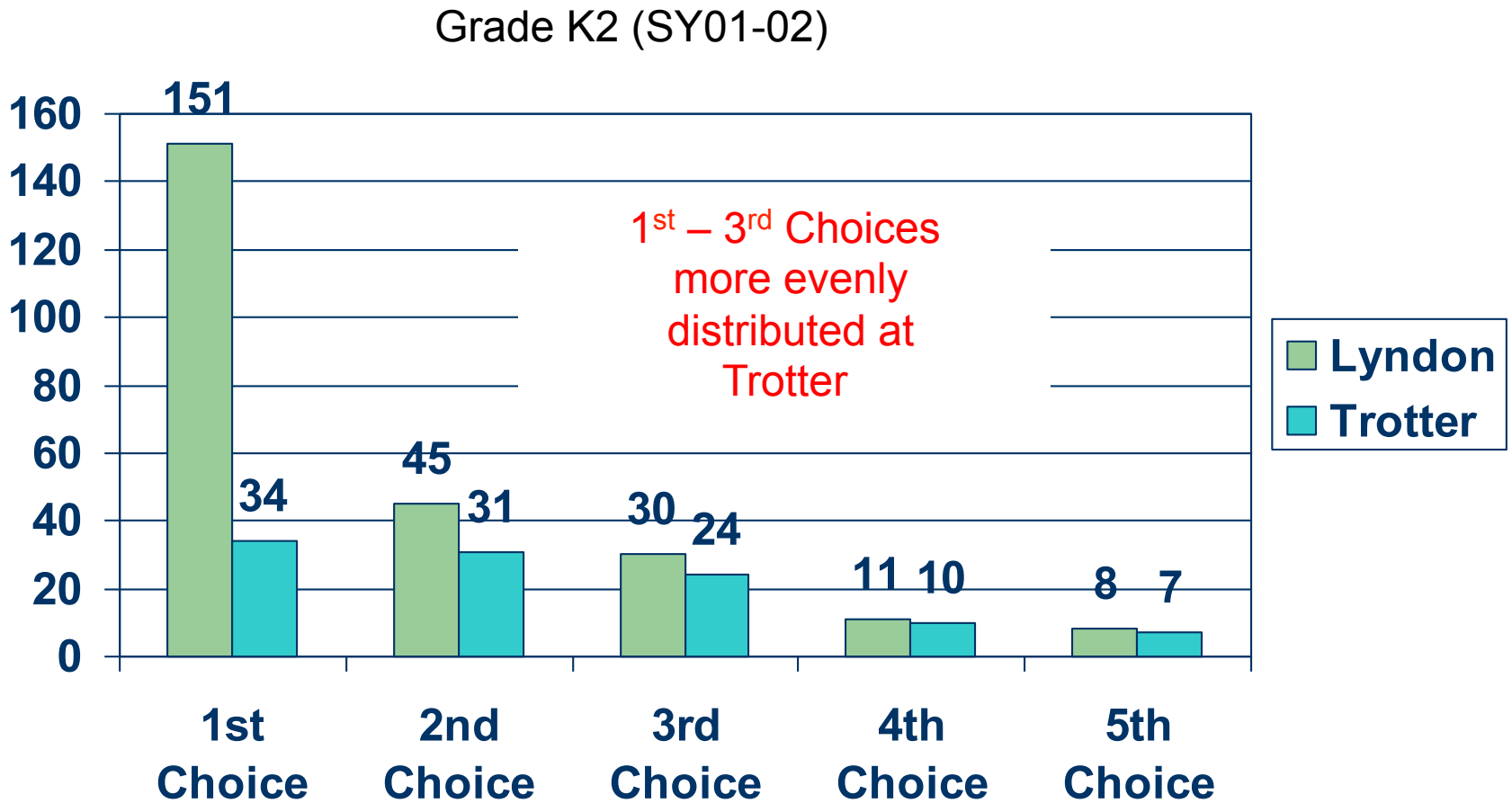
- The percentage of students receiving their ‘first choice’ using the Boston Mechanism is overstated, as compared to the two alternate mechanisms.
  - Initial evidence and theory suggests because of some level of strategizing, currently students *are only* receiving a high percentage of their stated first choices.
  - Students *are not* receiving a high percentage of their true first choices. (i.e. “where they rather go” vs. “where they think they can get in.”)
- This deficiency will be completely removed under a strategy-proof algorithm as it responds to a student’s true choices, and not their strategized choices.

A Smaller Percentage Of Over-demanded Schools Are Ranked As Second And Third Choices



*Based on previous year's choice figures. **'Other' includes times when no 2nd or 3rd choice is made.

Example: Lyndon Receives Far Fewer 2nd and Higher Choices Than 1st Choices, Compared to Trotter



Seat Capacity: Lyndon = 50 Seats, Trotter = 51

Current Situation: First Choice, First Served

- The Boston Mechanism looks at everyone's first choice school first, and assigns based on priorities and random numbers.

- If a student is *not* assigned during the first pass, they face the likelihood of having their 2nd, 3rd and even 4th choice schools filled if the family selects over-demanded schools that other's have made their first choice.

Under The Current Algorithm, Parents Who Are "Risk Takers" Often Suffer

- Roughly 45% of students who received their third choice or lower would have benefited from removing an over-demanded school as their top choice.

- Example: A parent made the following choices:
  1. Young Achievers…...(Over-demanded, with limited number of seats)
  2. Timilty
  3. Harbor
  4. McCormack
  5. Lewenberg….(Assigned School)

- Because of an average lottery number, this student was not assigned to Young Achievers, but instead was assigned to the 5th choice school, the Lewenberg.

This "Risk Taker" Could Have Done Better

- In our example, if the parent had removed Young Achievers as a first choice and moved up all other choices, the same lottery number would have secured a spot in the Timilty.

- The parent would have gotten the Timilty:
  1. Timilty…….(originally, the number 2 choice)
  2. Harbor
  3. McCormack
  4. Lewenberg

Anticipated Outcomes of an Algorithm Change:

1. The adoption of a strategy-proof algorithm (Gale-Shapley Deferred Acceptance Mechanism or the Top Trading Cycles Mechanism) will take the high-stakes gamble out of the assignment process.

2. Since a strategy-proof algorithm eliminates the need for strategizing, parents will no longer be discouraged from putting a more popular school as their first choice. Selection habits will change, and fewer students are expected receive their first choice school if more people are vying for seats in over-demanded schools.

Anticipated Outcomes of an Algorithm Change:

3. The number of school choices made by families is likely to increase, as parents will be more inclined to list *all* schools they are interested in, not just those to which they are more likely to gain admittance.

4. BPS will have to effectively inform families of the algorithm change and actively encourage them to choose from eight to ten schools (at the elementary level) on their application forms.

5. A family submitting a short list of highly chosen schools will dramatically increase their chances of receiving an administrative assignment.

Conclusion

- The current BPS assignment algorithm makes it risky for parents to rank an over-demanded school first, unless they have a high priority at that school.
- A Strategy-Proof Algorithm:
  - Removes the risk from ranking schools in order of true preference.
  - Eliminates the need for strategizing.
  - Adds "transparency" and clarity to the assignment process, by allowing for clear and straight forward advice to parents regarding how to rank schools.
  - "Levels the playing field" by diminishing the harm done to parents who do not strategize or do not strategize well.

IV. Recommendation: Gale-Shapley

- The Gale-Shapley *Deferred Acceptance Algorithm* will best serve Boston families, as a centralized procedure by which seats are assigned to students based on both student preferences and their sibling, walk zone and random number priorities.
- Students will receive their highest choice among their school choices for which they have high enough priority to be assigned. The final assignment has the property that a student is not assigned to a school that he would prefer **only** if every student who is assigned to that school has a higher priority at that school.
- Regardless of what other students do, this assignment procedure allows all students to rank schools in their true order of preference, without risk that this will give them a worse assignment than they might otherwise get.

Why *Not* Top Trading Cycles?

- The Top Trading Cycles Algorithm allows students to trade their priority for a seat at a school with another student. This trading shifts the emphasis onto the priorities and away from the goals BPS is trying to achieve by granting these priorities in the first place.
- This trading of priorities could lead families to believe they can still benefit from strategizing, as they may be encouraged to rank schools to which they have priority, even if they would not have put it on the form if the opportunity for trading did not exist.
- The behind the scenes mechanized trading makes the student assignment process less transparent.

V. Next Steps

- Presuming the School Committee agrees with changing the algorithm, the Committee would engage in a public process to present the findings and rationale for making the change.
- BPS staff will develop a strategy for implementing an algorithm change for the SY06-07 registration process, that begins in January 2006. The implementation strategy will include:
  - After further determining the extent of the effort required to program the new algorithm, a plan to complete the change by December 2005.
  - A comprehensive communications plan that will inform parents of the algorithm change and how best to make their school choices.

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Questions?