*Can we assess learning outcomes **at scale** without using exams?*

Can Game Theory Provide Answers?

G Venkatesh

CEO Mylspot and
Professor of Practice, HSS, IIT Madras

THE ANITA STORY

Anita S, A poor Dalit student from Ariyalur, TN committs suicide on Sep 1, 2017.

Did not perform well in NEET exam – new requirement for medical college admissions.

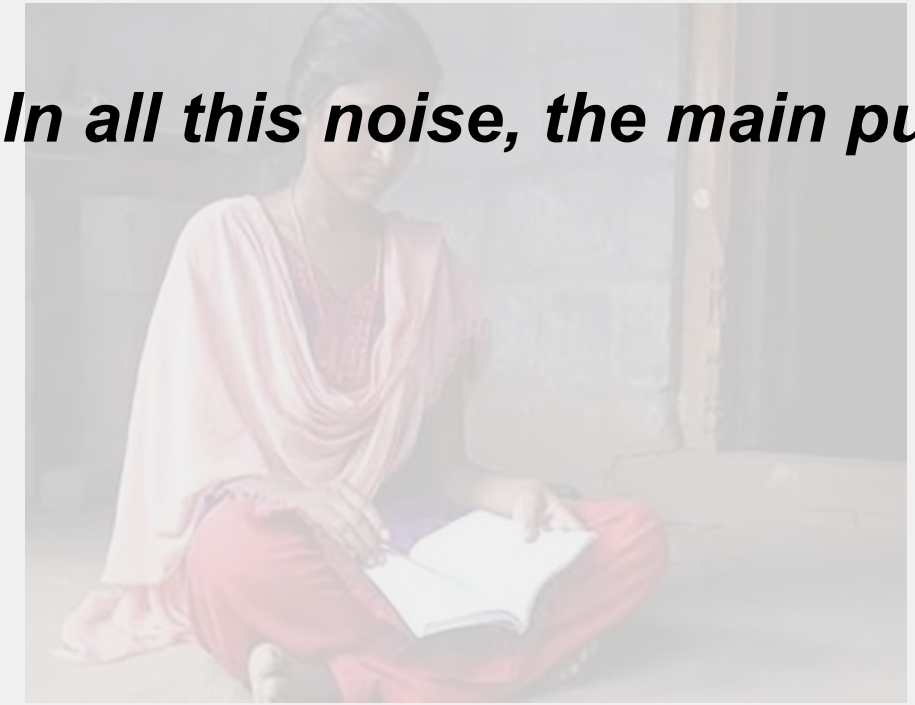
She had secured 1176/1200 in state board exam, which under old rules would have secured a seat

Govt: Medical seats needed to meet shortfall of doctors (esp in rural areas)

Parents: Medical college as a equitable means to achieve social mobility

Why do we have tests and exams?

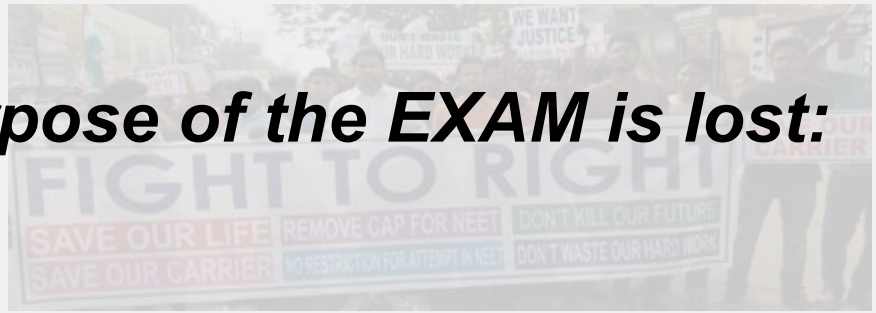
In all this noise, the main purpose of the EXAM is lost:



Anita S, A poor Dalit student from Ariyalur, TN committs suicide on Sep 1, 2017.

Did not perform well in NEET exam – new requirement for medical college admissions.

She had secured 1176/1200 in state board exam, which under old rules would have secured a seat



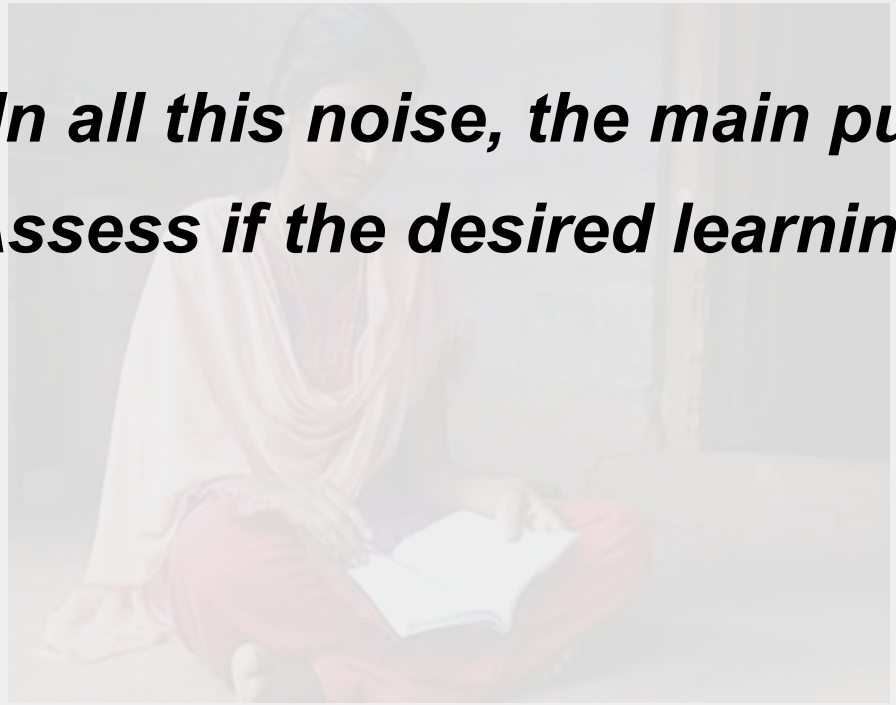
Govt: Medical seats needed to meet shortfall of doctors (esp in rural areas)

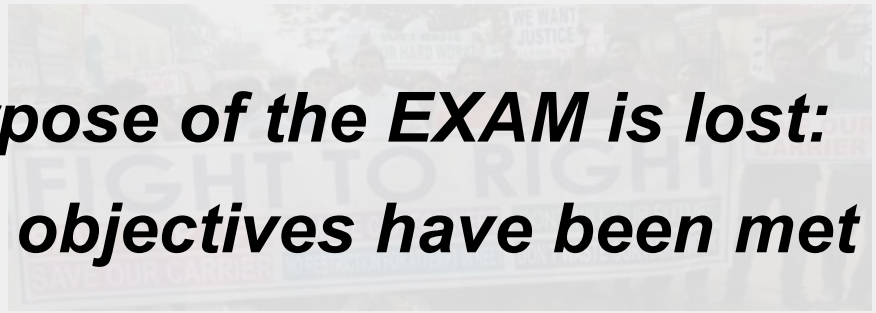
Parents: Medical college as a equitable means to achieve social mobility mobility

Why do we have tests and exams?

In all this noise, the main purpose of the EXAM is lost:

Assess if the desired learning objectives have been met





Anita S, A poor Dalit student from Ariyalur, TN committs suicide on Sep 1, 2017.

Did not perform well in NEET exam – new requirement for medical college admissions.

She had secured 1176/1200 in state board exam, which under old rules would have secured a seat

Govt: Medical seats needed to meet shortfall of doctors (esp in rural areas)

Parents: Medical college as a equitable means to achieve social mobility mobility

Why do we have tests and exams?

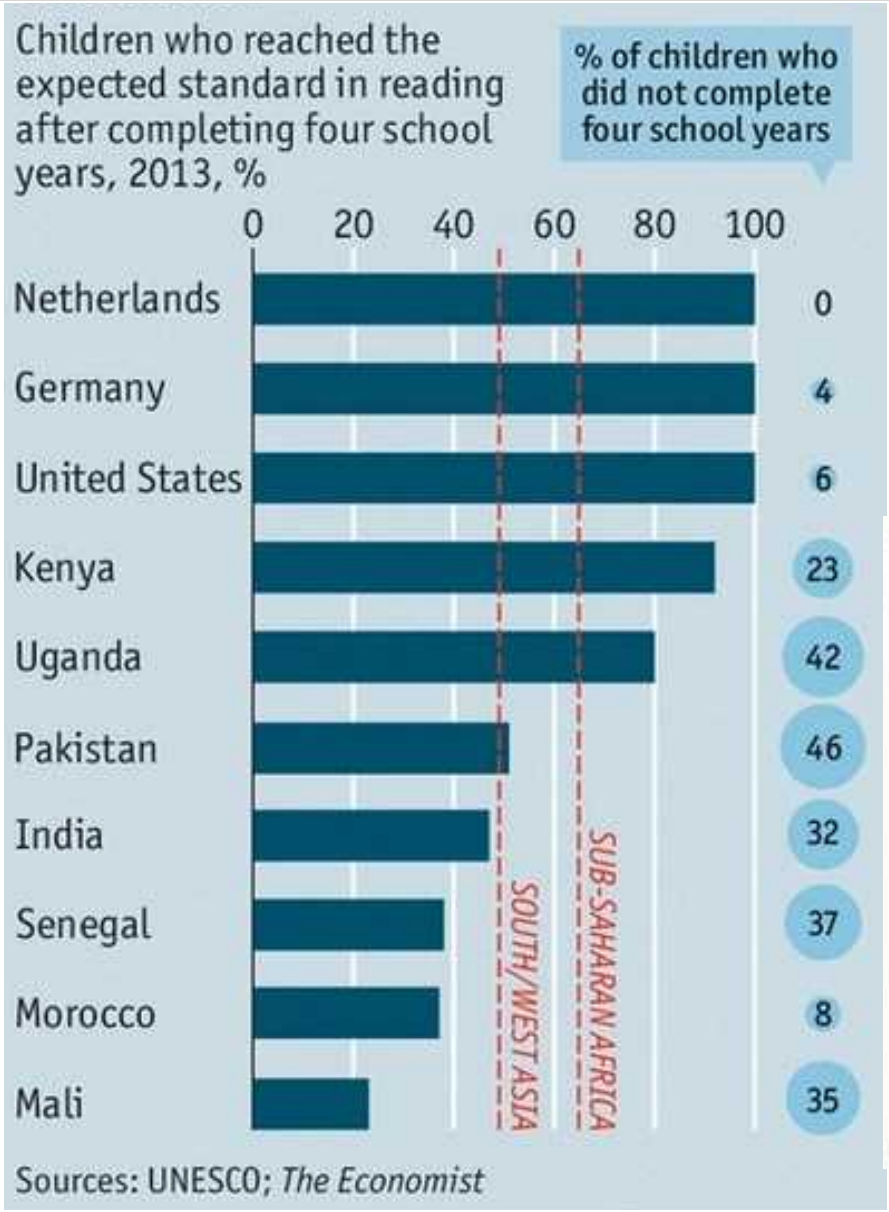
In all this noise, the main purpose of the EXAM is lost:

Assess if the desired learning objectives have been met

In contrast, it has led to undesirable outcomes

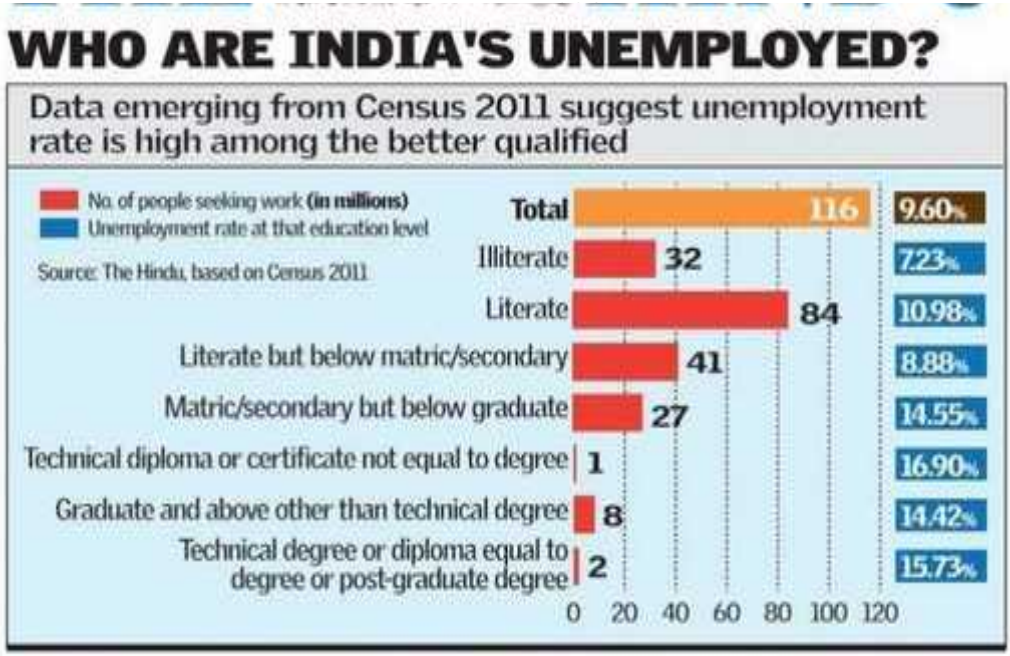
- Schools and colleges are forced to focus on exam syllabus coverage and rote learning methods; internal assessments become means to get higher marks for their students
- Parents/students increasingly turn to private tuition and exam preparation centres to improve competitive scores in exams
- Employers place little value on skills through school/college learning; forced to choose "over-qualified" people for low level jobs
- Government, caught between conflicting interests, driven to short term gains by focusing on quantity – higher enrollment and more infrastructure

Resulting in low learning outcomes



Task	All youth	Male	Female
Counting money	75.7	82.4	69.9
Adding weights	55.7	67.5	45.4
Telling time (hour)	82.7	86.2	79.6
Telling time (hour and minutes)	59.3	66.4	53.1

Source: ASER report

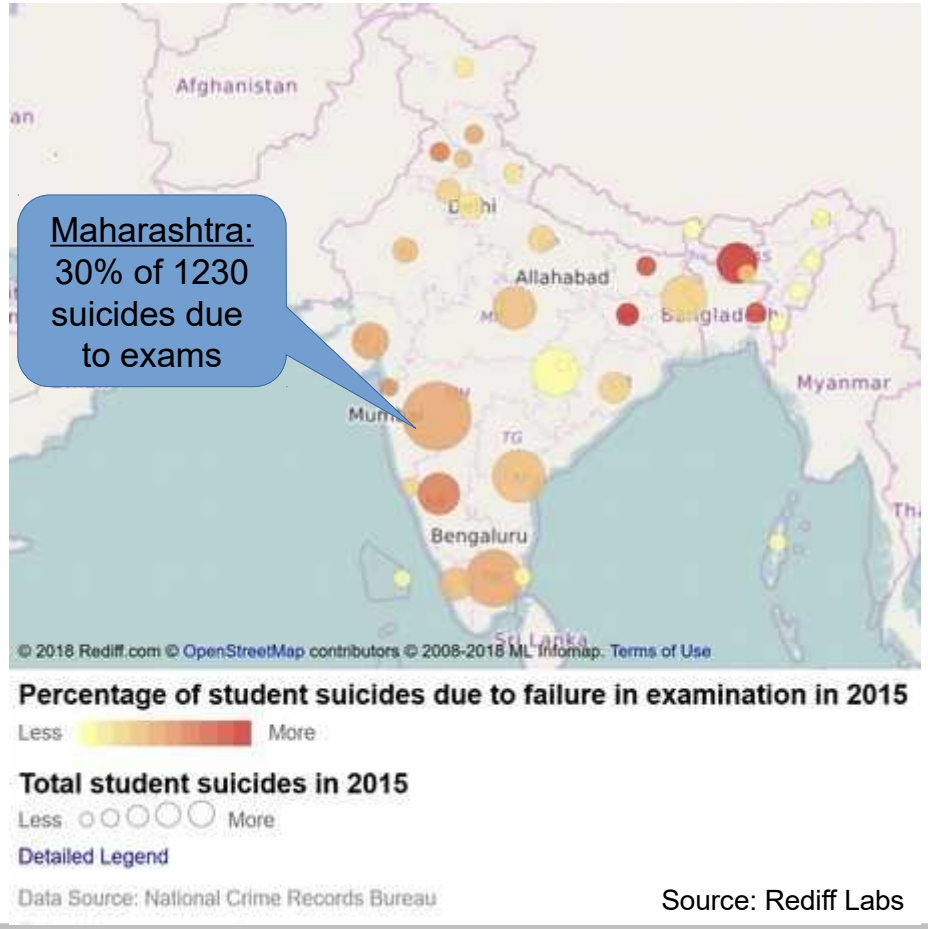


Source: Hindu

Yet, focus on exams is getting worse ...

- No Detention Policy being reversed – exams for 5th and 8th
- Exams for 11th standard to make students "learn" 11th portions, so they can be prepared for competitive exams

Its now established that high-stakes testing (large scale competitive exams) creates collateral damage: e.g. suicides



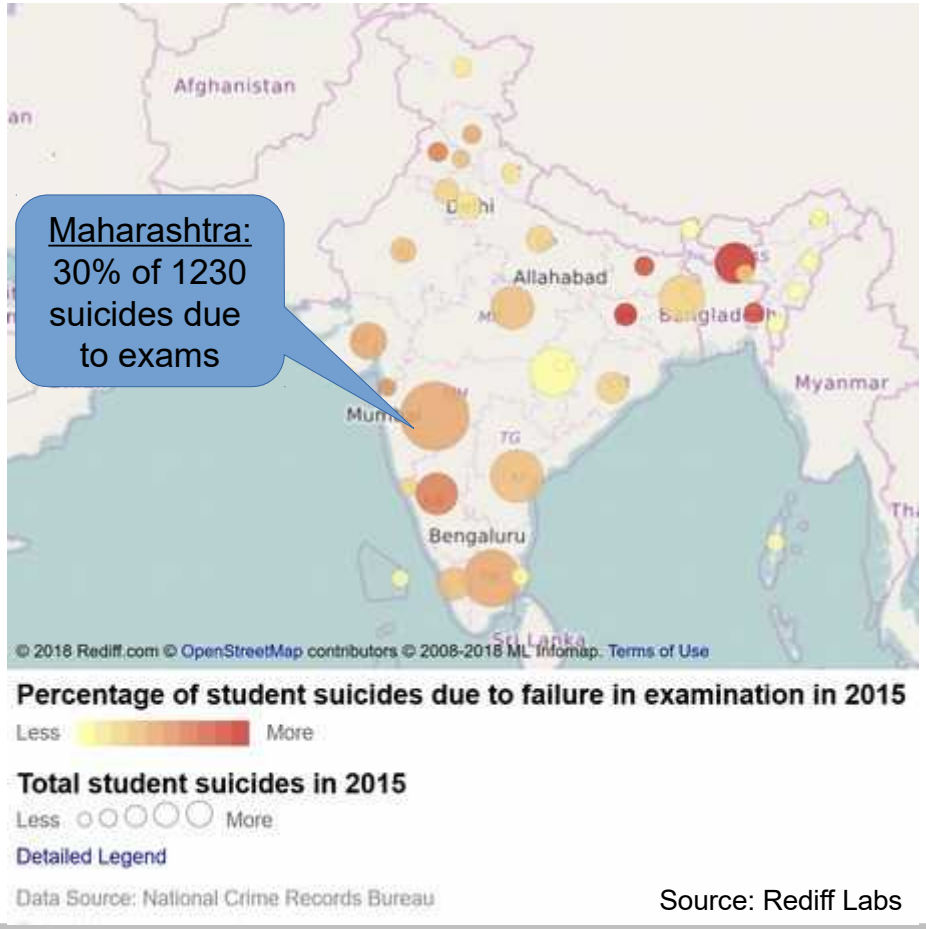
Source: Rediff Labs

Yet, focus on exams is getting worse ...

- No Detention Policy being reversed – exams for 5th and 8th
- Exams for 11th standard to make students "learn" 11th portions, so they can be prepared for competitive exams

Its now established that high-stakes testing (large scale competitive exams) creates collateral damage: e.g. suicides

The least we can do, is to provide multiple opportunities for students to take the high-stakes test



Source: Rediff Labs

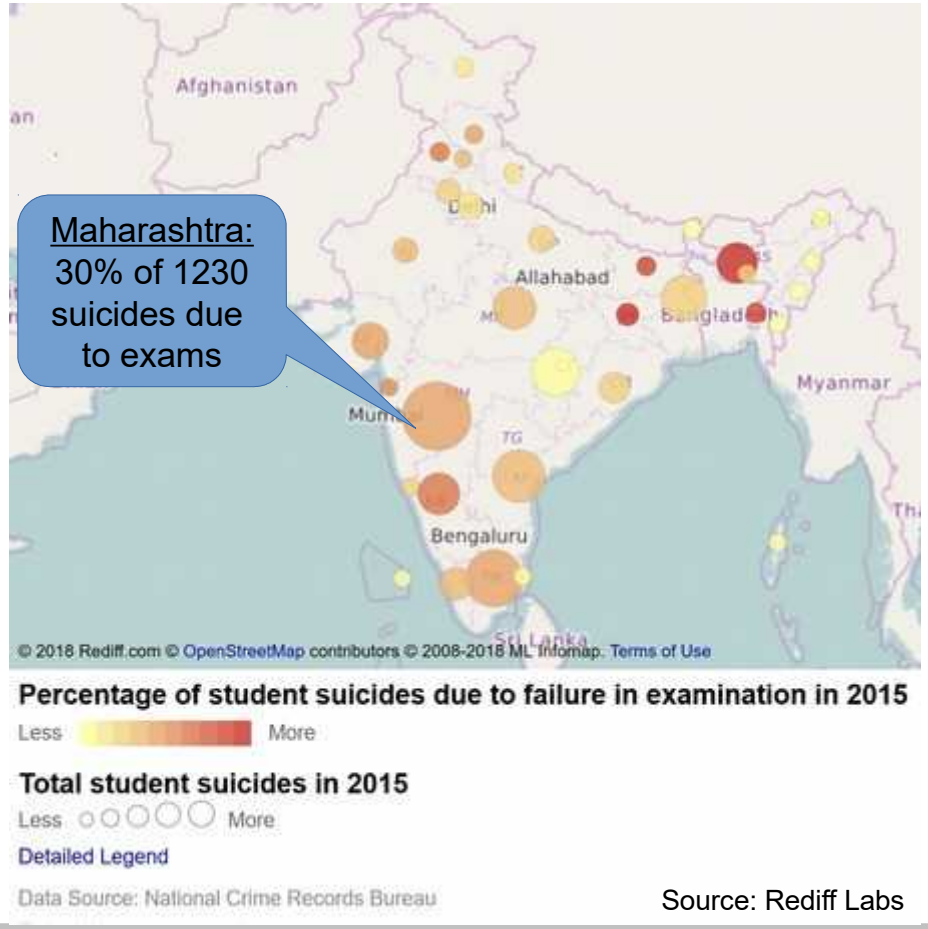
Yet, focus on exams is getting worse ...

- No Detention Policy being reversed – exams for 5th and 8th
- Exams for 11th standard to make students "learn" 11th portions, so they can be prepared for competitive exams

Its now established that high-stakes testing (large scale competitive exams) creates collateral damage: e.g. suicides

The least we can do, is to provide multiple opportunities for students to take the high-stakes test

But we run into a problem: Multiple tests lead to disputes about fairness ! e.g. SC ruling on NEET in local languages



Source: Rediff Labs

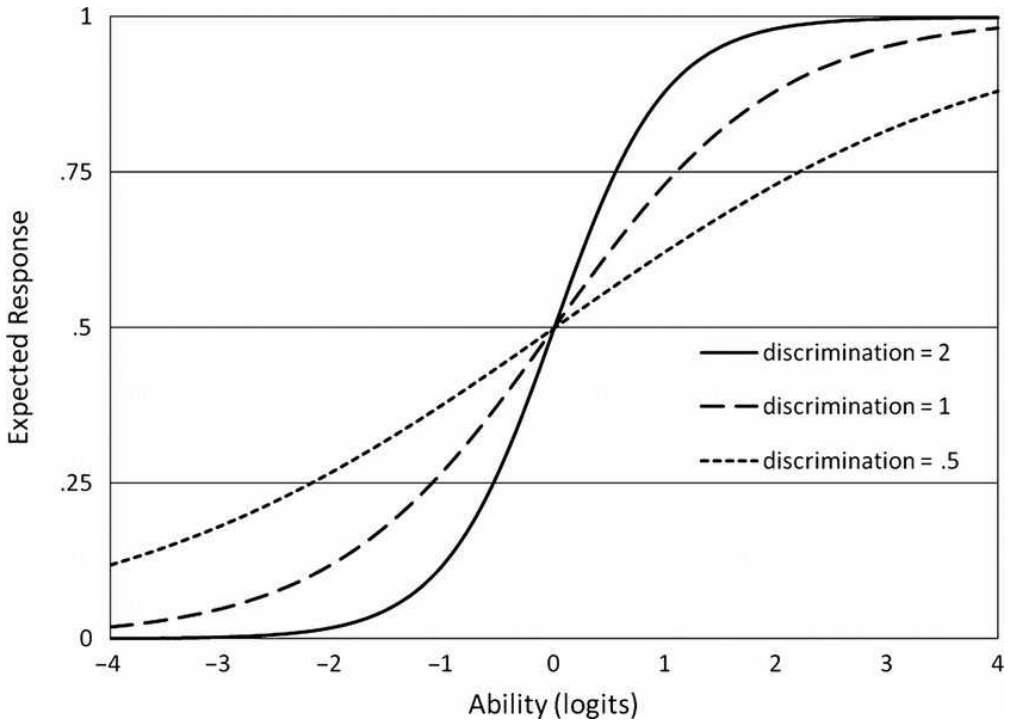
Equivalence vs normalisation

Equivalence of questions

- same topic and similar success/ failure rates across a large population
- IRT can be used for this
- Tests with equivalent questions are equivalent

Equivalence by normalisation

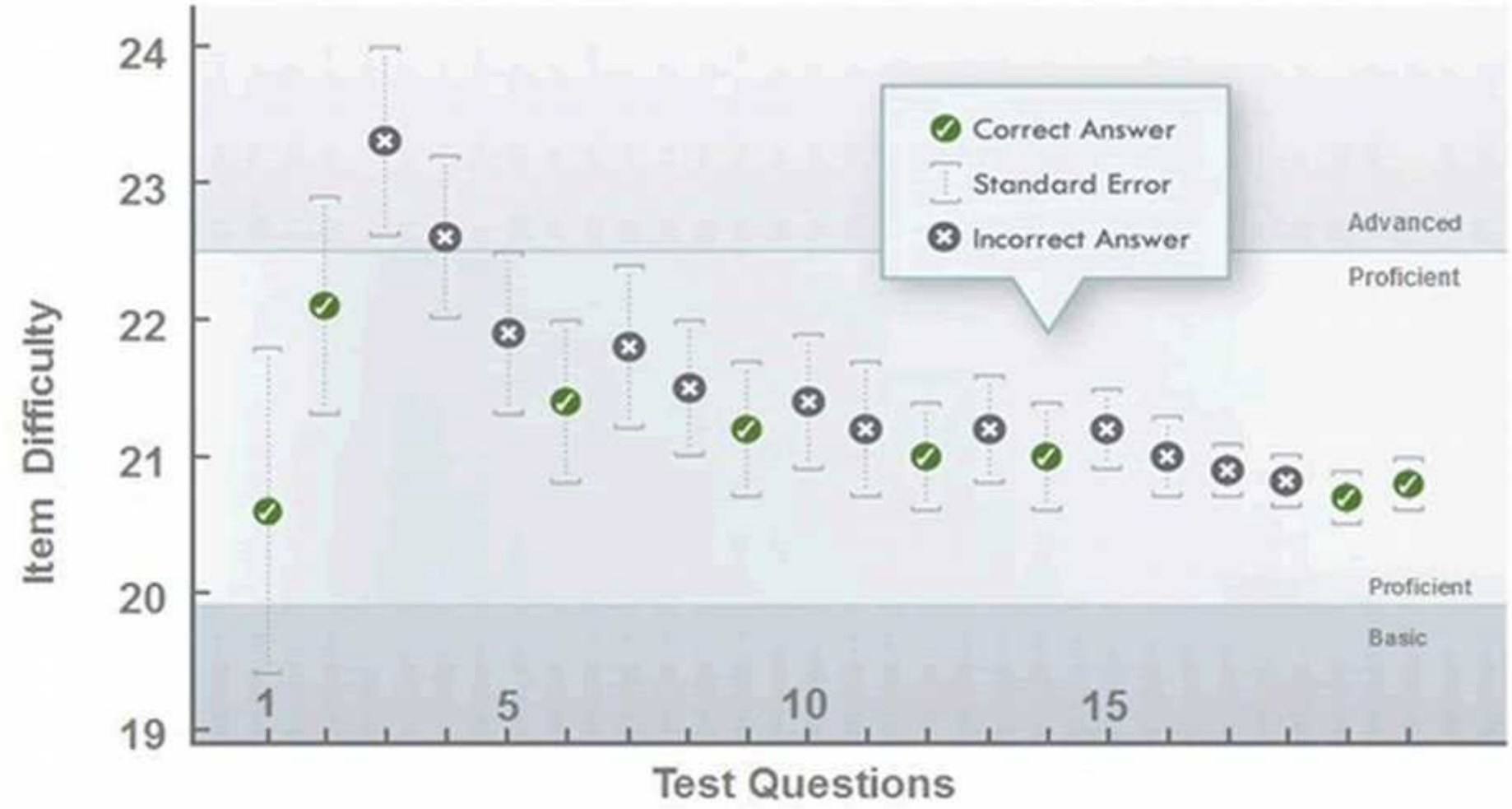
- Ensure large population for each of the tests (random allocation)
- Fit results into a distribution (e.g. GATE)



Item response theory

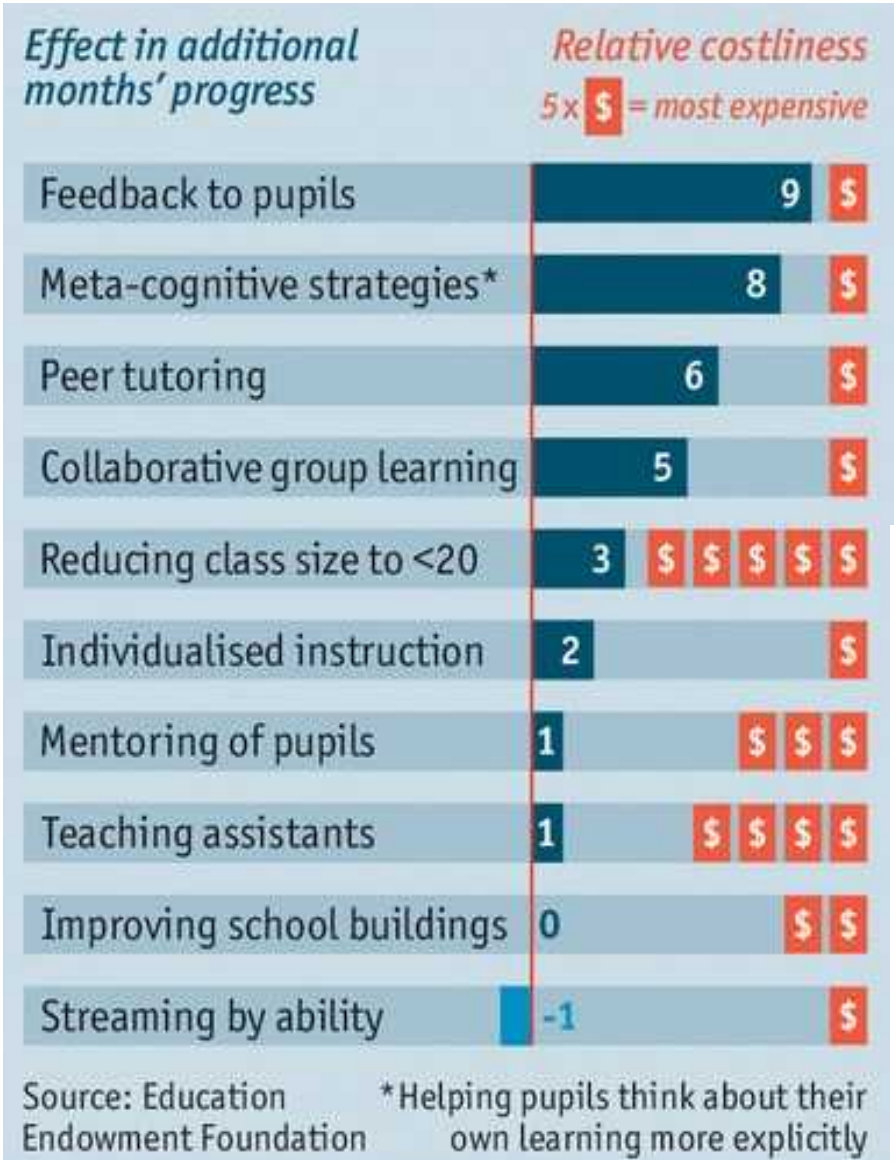
Getting public acceptance of either of these is not easy

Computer adaptive testing

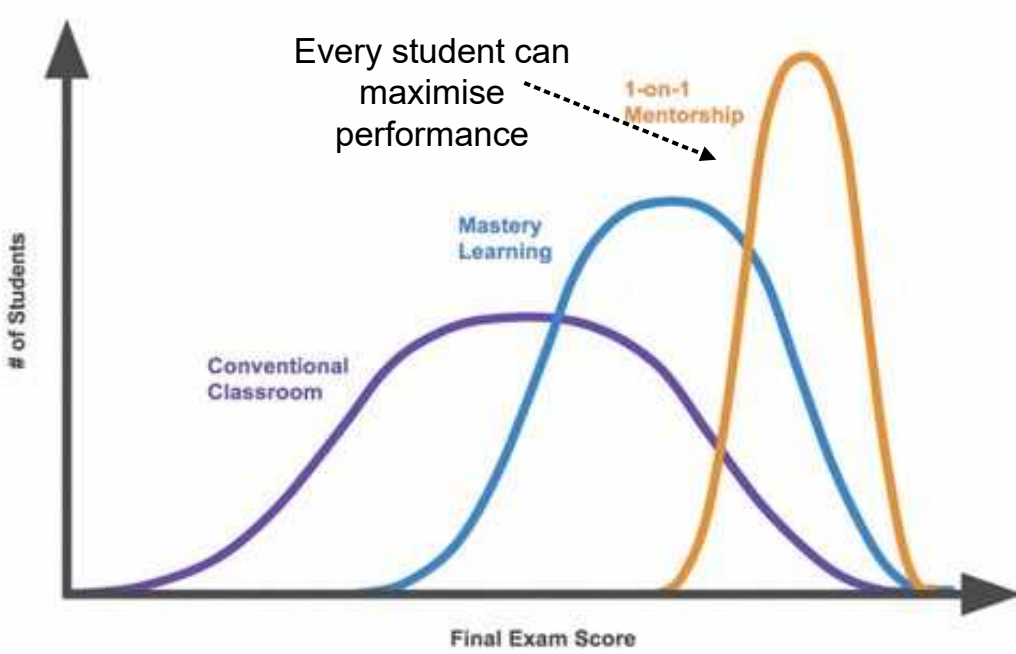


Converges quickly to the ability level (min no of questions)

Learning: Feedback/reflection work best



School	Formative Assessments
College	?



Source: Economist

Getting back to the topic ...

*Can we assess learning outcomes **at scale** without using the conventional form of exams?*

Why is this important?

Focus on exams by students, parents, teachers, institutions has perversely altered behaviour - leading to lack of motivation to improve learning outcomes

And it is getting worse ...

- No Detention Policy being reversed – exams for 5^{th} and 8^{th}
- Exams for 11^{th} standard to make students "learn" 11^{th} portions, so they can be prepared for competitive exams

Can Game Theory provide any useful perspectives?

Significant game theory insights

Information asymmetry: employee's ability cannot be fully evaluated by employer through interviews

Adverse Selection: "The market for lemons" Akerlof (1970)

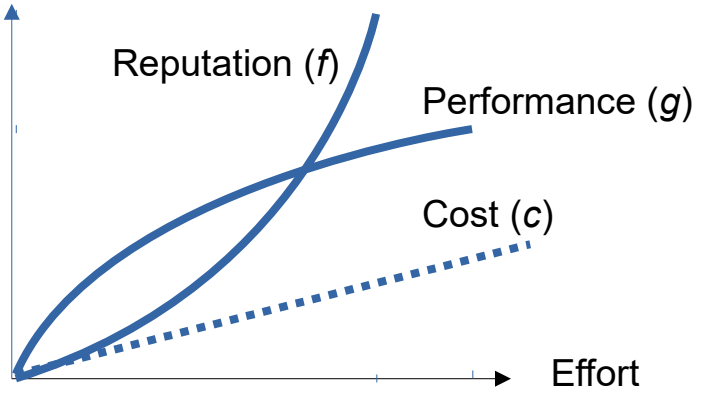
- Firms are unable to distinguish skilled ("good") from unskilled ("bad"); at best they could make an estimate of the ratio of "good" to "bad" in the incoming population, and use this to set the wage. But this creates perverse incentives for an entrant to choose to be "bad" since it comes at much lower cost than to choose to be "good".
- Equilibrium: Entrants choose to be "bad" and firms only pay for low quality – i.e. the "bad" drive out the "good" from the market

Job market signalling: Spence 1973

- Old equilibrium: Entrants choose to be “bad” and firms only pay for low quality – i.e. the “bad” drive out the “good” from the market. Can the “good” do anything to change this equilibrium?
- Yes they can – they can ***signal*** their quality – through certifications (higher degrees from reputed institutions).
- The “cost” to acquire these degrees is much higher for the “bad”, who choose not to acquire these certifications. Employers can thus use the signal (certifications) as a credible means to distinguish “good” from “bad”. Thus the “good” (those with certifications) get higher wages and better positions compared to the “bad” (those without).
- If the difference in wage between “good” and “bad” becomes too high, the “bad” will also be incentivised to acquire the certifications – again making the signal non-credible and forcing the wages to settle to lower levels.
- Which further forces the “good” to seek even more credentials.
- A serious consequence of this: acquiring degrees and credentials seen to be more important than learning.

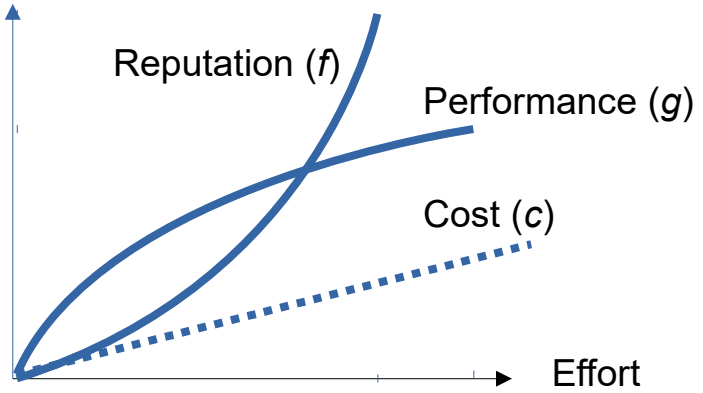
A game theoretic model

- Two kinds of players: institutions and students.
- Institutions' choose the extent of effort *(e)* to be put into ensuring that students learn **(Reputation factor).** Balance (*1-e*) effort is spent in training the students to perform in the exams **(Performance factor)**.
- Student's give weight *a* to reputation and weight *(1-a)* to performance.
- Effort on Learning $\xrightarrow{p}$ Exam Performance
- Effort on Exams $\xrightarrow{q}$ Learning
- Student payoff:
  $S(e,a) = a*f(e + q(1-e)) + (1-a)*g(1-e + p*e)$
- Institution payoff: $I(e,a) = S(e,a) – c(e)$



A GAME THEORETIC MODEL

- Two kinds of players: institutions and students.
- Institutions' choose the extent of effort *(e)* to be put into ensuring that students learn **(Reputation factor).** Balance (*1-e*) effort is spent in training the students to perform in the exams **(Performance factor)**.
- Student's give weight *a* to reputation and weight *(1-a)* to performance.
- Effort on Learning $\xrightarrow{p}$ Exam Performance
- Effort on Exams $\xrightarrow{q}$ Learning
- Student payoff:
  $S(e,a) = a*f(e + q(1-e)) + (1-a)*g(1-e + p*e)$
- Institution payoff: $I(e,a) = S(e,a) - c(e)$

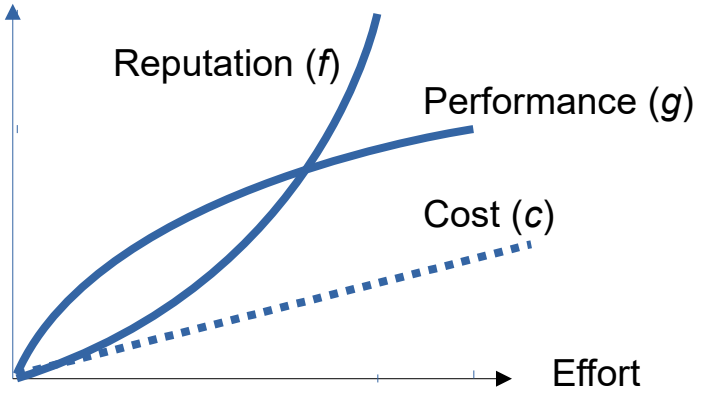


Payoff table	Institution I1 ($e = 0$)	Institution I2 ($e = 1$)
Student S1 ($a = 0$)		
Student S2 ($a = 1$)		

$f(x) = x^2$ $g(x) = \sqrt{x}$ $c(x) = x$ $p = q = 0.5$

A GAME THEORETIC MODEL

- Two kinds of players: institutions and students.
- Institutions' choose the extent of effort *(e)* to be put into ensuring that students learn **(Reputation factor).** Balance (*1-e*) effort is spent in training the students to perform in the exams **(Performance factor)**.
- Student's give weight *a* to reputation and weight *(1-a)* to performance.
- Effort on Learning $\xrightarrow{p}$ Exam Performance
- Effort on Exams $\xrightarrow{q}$ Learning
- Student payoff:
  $S(e,a) = a*f(e + q(1-e)) + (1-a)*g(1-e + p*e)$
- Institution payoff: $I(e,a) = S(e,a) – c(e)$

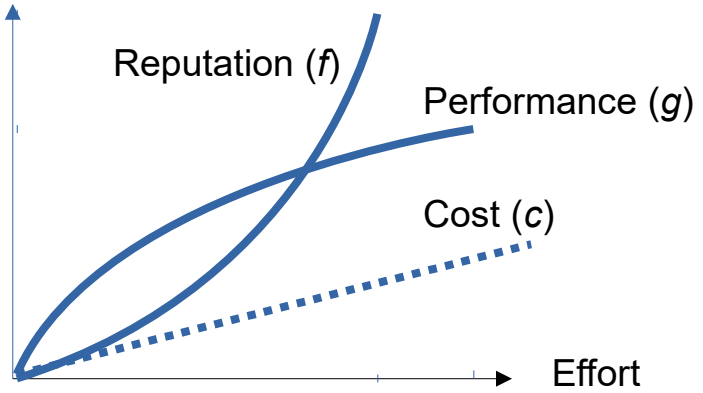


Payoff table	Institution I1 ($e = 0$)	Institution I2 ($e = 1$)
Student S1 ($a = 0$)	1, 1	0.7, -0.3
Student S2 ($a = 1$)	0.25, 0.25	1, 0

$f(x) = x^2$ $g(x) = \sqrt{x}$ $c(x) = x$ $p = q = 0.5$

A GAME THEORETIC MODEL

- Two kinds of players: institutions and students.
- Institutions' choose the extent of effort *(e)* to be put into ensuring that students learn **(Reputation factor).** Balance (*1-e*) effort is spent in training the students to perform in the exams **(Performance factor)**.
- Student's give weight *a* to reputation and weight *(1-a)* to performance.
- Effort on Learning $\xrightarrow{p}$ Exam Performance
- Effort on Exams $\xrightarrow{q}$ Learning
- Student payoff:
  $S(e,a) = a*f(e + q(1-e)) + (1-a)*g(1-e + p*e)$
- Institution payoff: $I(e,a) = S(e,a) – c(e)$



Payoff table	Institution I1 (*e* = 0)	Institution I2 (*e* = 1)
Student S1 (*a* = 0)	1, 1	0.7, -0.3
Student S2 (*a* = 1)	0.25, 0.25	1, 0

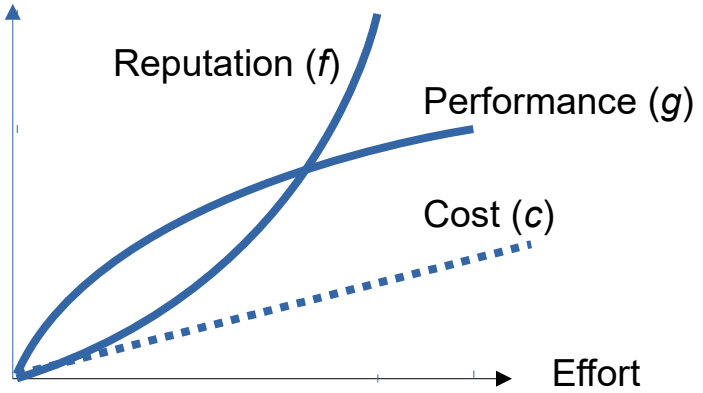
I1 dominates I2 — *Institutions focus on exams*

S1 dominates S2 — *Students value only exams*

$f(x) = x^2$ $g(x) = \sqrt{x}$ $c(x) = x$ $p = q = 0.5$

A GAME THEORETIC MODEL

- Two kinds of players: institutions and students.
- Institutions' choose the extent of effort *(e)* to be put into ensuring that students learn **(Reputation factor).** Balance (*1-e*) effort is spent in training the students to perform in the exams **(Performance factor)**.
- Student's give weight *a* to reputation and weight *(1-a)* to performance.
- Effort on Learning $\xrightarrow{p}$ Exam Performance
- Effort on Exams $\xrightarrow{q}$ Learning
- Student payoff:
  $S(e,a) = a*f(e + q(1-e)) + (1-a)*g(1-e + p*e)$
- Institution payoff: $I(e,a) = S(e,a) - c(e)$



Payoff table	Institution I1 (*e* = 0)	Institution I2 (*e* = 1)
Student S1 (*a* = 0)	1, 1	0.7, -0.3
Student S2 (*a* = 1)	0.25, 0.25	1, 0

I1 dominates I2 — *Institutions focus on exams*

S1 dominates S2 — *Students value only exams*

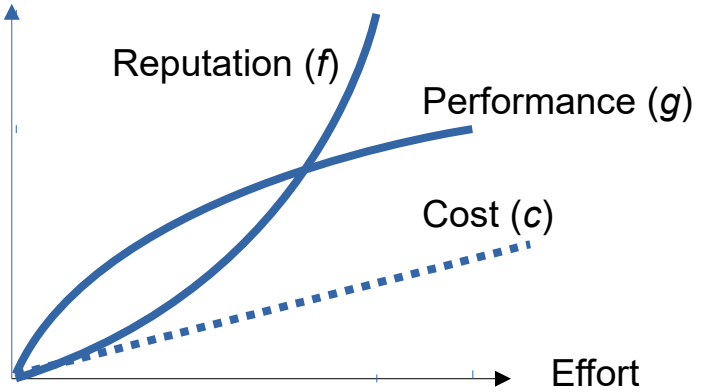
Model fits the scenario presented earlier

$f(x) = x^2$ $g(x) = \sqrt{x}$ $c(x) = x$ $p = q = 0.5$

A GAME THEORETIC MODEL

- Two kinds of players: institutions and students.
- Institutions' choose the extent of effort *(e)* to be put into ensuring that students learn **(Reputation factor).** Balance (*1-e*) effort is spent in training the students to perform in the exams **(Performance factor)**.
- Student's give weight *a* to reputation and weight *(1-a)* to performance.
- Effort on Learning $\xrightarrow{p}$ Exam Performance
- Effort on Exams $\xrightarrow{q}$ Learning
- Student payoff: $S(e,a) = a\,I(e + q(1-e)) + (1-a)\,g(1-e + pe)$
- Institution payoff: $I(e,a) = S(e,a) - c(e)$

Economy of Scale or Technology drives down cost of learning



Payoff table	Institution I1 (e = 0)	Institution I2 (e = 1)
Student S1 (a = 0)	1, 1	0.7, -0.3
Student S2 (a = 1)	0.25, 0.25	1, 0

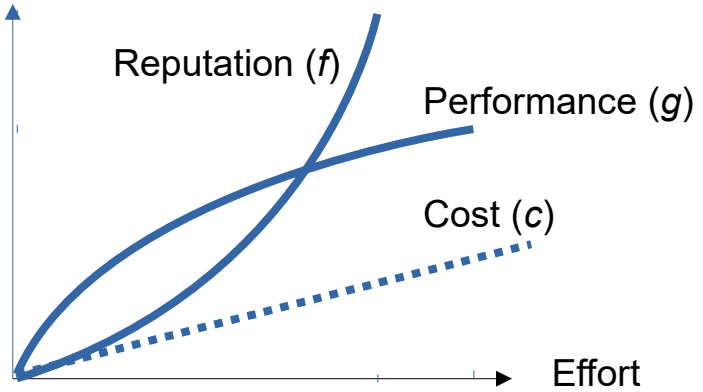
$f(x) = x^2$ $g(x) = \sqrt{x}$ $c(x) = x$ $p = q = 0.5$

Payoff table	Institution I1 (e = 0)	Institution I2 (e = 1)
Student S1 (a = 0)		
Student S2 (a = 1)		

$f(x) = x^2$ $g(x) = \sqrt{x}$ $c(x) = 0.5x$ $p = q = 0.5$

A GAME THEORETIC MODEL

- Two kinds of players: institutions and students.
- Institutions' choose the extent of effort *(e)* to be put into ensuring that students learn **(Reputation factor).** Balance (*1-e*) effort is spent in training the students to perform in the exams **(Performance factor)**.
- Student's give weight *a* to reputation and weight *(1-a)* to performance.
- Effort on Learning $\xrightarrow{p}$ Exam Performance
- Effort on Exams $\xrightarrow{q}$ Learning
- Student payoff:
  $S(e,a) = a*f(e + q(1-e)) + (1-a)*g(1-e + p*e)$
- Institution payoff: $I(e,a) = S(e,a) – c(e)$



Payoff table	Institution I1 (*e* = 0)	Institution I2 (*e* = 1)
Student S1 (*a* = 0)	1, 1	0.7, -0.3
Student S2 (*a* = 1)	0.25, 0.25	1, 0

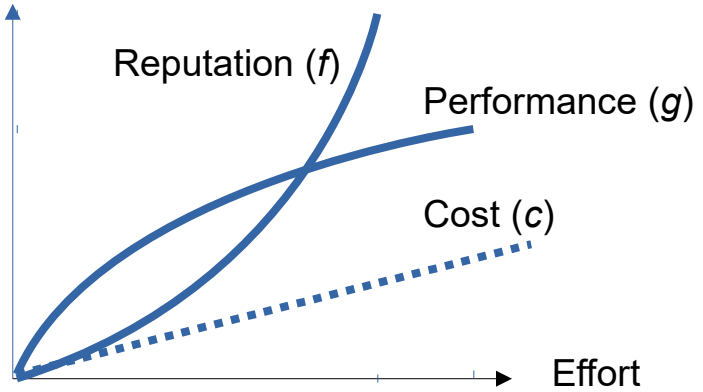
$f(x) = x^2$ $g(x) = \sqrt{x}$ $c(x) = x$ $p = q = 0.5$

Payoff table	Institution I1 (*e* = 0)	Institution I2 (*e* = 1)
Student S1 (*a* = 0)	1, 1	0.7, 0.2
Student S2 (*a* = 1)	0.25, 0.25	1, 0.5

$f(x) = x^2$ $g(x) = \sqrt{x}$ $c(x) = 0.5x$ $p = q = 0.5$

A GAME THEORETIC MODEL

- Two kinds of players: institutions and students.
- Institutions' choose the extent of effort *(e)* to be put into ensuring that students learn **(Reputation factor).** Balance (*1-e*) effort is spent in training the students to perform in the exams **(Performance factor)**.
- Student's give weight *a* to reputation and weight *(1-a)* to performance.
- Effort on Learning $\xrightarrow{p}$ Exam Performance
- Effort on Exams $\xrightarrow{q}$ Learning
- Student payoff:
  $S(e,a) = a*f(e + q(1-e)) + (1-a)*g(1-e + p*e)$
- Institution payoff: $I(e,a) = S(e,a) – c(e)$



Payoff table	Institution I1 (*e* = 0)	Institution I2 (*e* = 1)
Student S1 (*a* = 0)	1, 1	0.7, -0.3
Student S2 (*a* = 1)	0.25, 0.25	1, 0

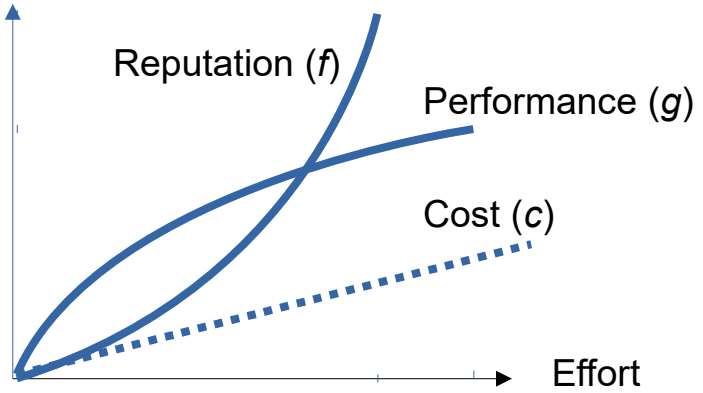
$f(x) = x^2$ $g(x) = \sqrt{x}$ $c(x) = x$ $p = q = 0.5$

Payoff table	Institution I1 (*e* = 0)	Institution I2 (*e* = 1)
Student S1 (*a* = 0)	1, 1	0.7, 0.2
Student S2 (*a* = 1)	0.25, 0.25	1, 0.5

$f(x) = x^2$ $g(x) = \sqrt{x}$ $c(x) = 0.5x$ $p = q = 0.5$

A GAME THEORETIC MODEL

- Two kinds of players: institutions and students.
- Institutions' choose the extent of effort *(e)* to be put into ensuring that students learn **(Reputation factor).** Balance (*1-e*) effort is spent in training the students to perform in the exams **(Performance factor)**.
- Student's give weight *a* to reputation and weight *(1-a)* to performance.
- Effort on Learning $\xrightarrow{p}$ Exam Performance
- Effort on Exams $\xrightarrow{q}$ Learning
- Student payoff:
  $S(e,a) = a*f(e + q(1-e)) + (1-a)*g(1-e + p*e)$
- Institution payoff: $I(e,a) = S(e,a) – c(e)$



A new solution: Institution focuses learning and Student chooses learning over exams

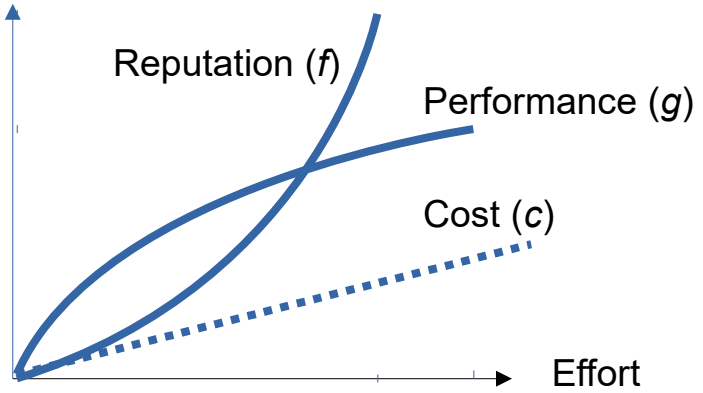
This model might explain the emergence of new specialised schools that focus all-round learning

Payoff table	Institution I1 (*e* = 0)	Institution I2 (*e* = 1)
Student S1 (*a* = 0)	1, 1	0.7, 0.2
Student S2 (*a* = 1)	0.25, 0.25	1, 0.5

$f(x) = x^2$ $g(x) = \sqrt{x}$ $c(x) = 0.5x$ $p = q = 0.5$

A GAME THEORETIC MODEL

- Two kinds of players: institutions and students.
- Institutions' choose the extent of effort *(e)* to be put into ensuring that students learn **(Reputation factor).** Balance (*1-e*) effort is spent in training the students to perform in the exams **(Performance factor)**.
- Student's give weight *a* to reputation and weight *(1-a)* to performance.
- Effort on Learning $\xrightarrow{p}$ Exam Performance
- Effort on Exams $\xrightarrow{q}$ Learning
- Student payoff:
  $S(e,a) = a*f(e + q(1-e)) + (1-a)*g(1-e + p*e)$
- Institution payoff: $I(e,a) = S(e,a) – c(e)$



A new solution: Institution focuses learning and Student chooses learning over exams

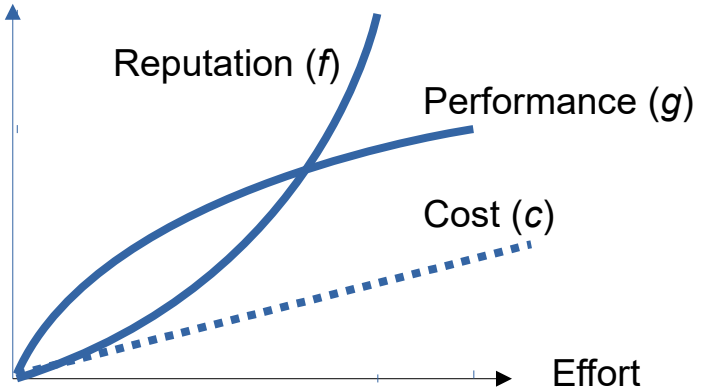
Usually, two solutions mean there is a better mixed strategy solution

Payoff table	Institution I1 (*e* = 0)	Institution I2 (*e* = 1)
Student S1 (*a* = 0)	1, 1	0.7, 0.2
Student S2 (*a* = 1)	0.25, 0.25	1, 0.5

$f(x) = x^2$ $g(x) = \sqrt{x}$ $c(x) = 0.5x$ $p = q = 0.5$

A GAME THEORETIC MODEL

- Two kinds of players: institutions and students.
- Institutions' choose the extent of effort *(e)* to be put into ensuring that students learn **(Reputation factor).** Balance (*1-e*) effort is spent in training the students to perform in the exams **(Performance factor)**.
- Student's give weight *a* to reputation and weight *(1-a)* to performance.
- Effort on Learning $\xrightarrow{p}$ Exam Performance
- Effort on Exams $\xrightarrow{q}$ Learning
- Student payoff:
  $S(e,a) = a*f(e + q(1-e)) + (1-a)*g(1-e + p*e)$
- Institution payoff: $I(e,a) = S(e,a) - c(e)$



However, the moment we introduce Ix that mixes I1 and I2 in ratio x,1-x, the solution will converge to x=1, i.e. S1,

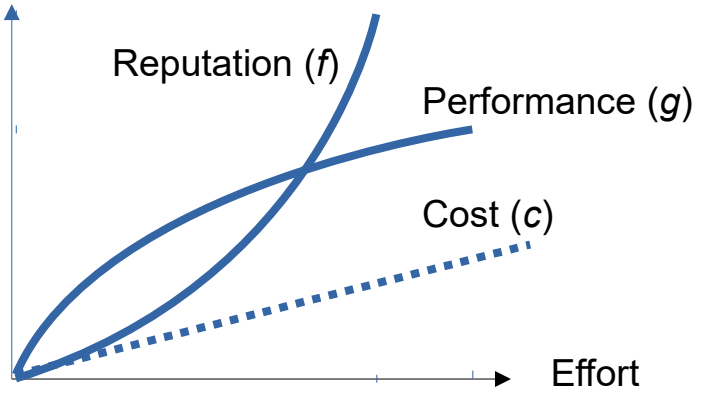
Entry of "Integrated schools" that mix exam preparation and learning – will they trend to exams only?

Payoff table	Institution I1 (*e* = 0)	Institution I2 (*e* = 1)
Student S1 (*a* = 0)	1, 1	0.7, 0.2
Student S2 (*a* = 1)	0.25, 0.25	1, 0.5

$f(x) = x^2$ $g(x) = \sqrt{x}$ $c(x) = 0.5x$ $p = q = 0.5$

A GAME THEORETIC MODEL

- Consider a 3rd type of player: firms.
- Firm hires *h* people from institutions focusing higher learning through say hands on programmes (*e*=1) assigning them a higher weight of 2, and the balance (*1-h*) from those with lower hands on programmes (*e*=0).
- Firm payoff: $F(e,a,h) = h*2*e + (1-h)*(1-e)$
- Student payoff: $S(e,a) = a*f(e + q(1-e)) + (1-a)*g(1-e + p*e)$
- Institution payoff: $I(e,a) = S(e,a) – c(e)$



Firm F1 (h=0)

Payoff table	Institution I1 (*e* = 0)	Institution I2 (*e* = 1)
Student S1 (*a* = 0)		
Student S2 (*a* = 1)		

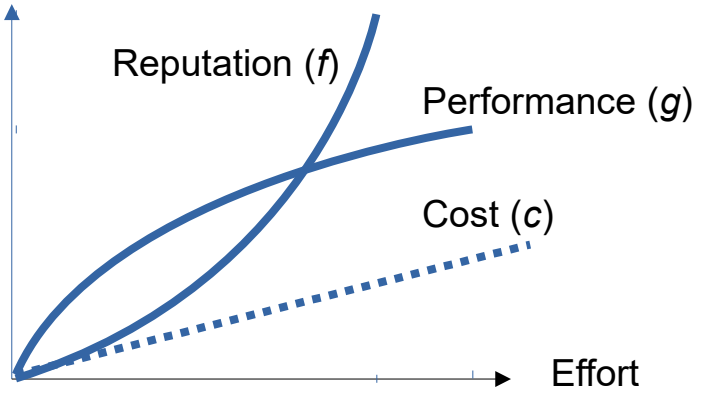
Firm F2 (h=1)

Payoff table	Institution I1 (*e* = 0)	Institution I2 (*e* = 1)
Student S1 (*a* = 0)		
Student S2 (*a* = 1)		

$f(x) = x^2$ $g(x) = \sqrt{x}$ $c(x) = 0.5x$ $p = q = 0.5$

A GAME THEORETIC MODEL

- Consider a 3rd type of player: firms.
- Firm hires *h* people from institutions focusing higher learning through say hands on programmes (*e*=1) assigning them a higher weight of 2, and the balance (*1-h*) from those with lower hands on programmes (*e*=0).
- Firm payoff: $F(e,a,h) = h*2*e + (1-h)*(1-e)$
- Student payoff: $S(e,a) = a*f(e + q(1-e)) + (1-a)*g(1-e + p*e)$
- Institution payoff: $I(e,a) = S(e,a) – c(e)$



Firm F1 (h=0)

Payoff table	Institution I1 (*e* = 0)	Institution I2 (*e* = 1)
Student S1 (*a* = 0)	1, 1, 1	0.7, 0.2, 0
Student S2 (*a* = 1)	0.25, 0.25, 1	1, 0.5, 0

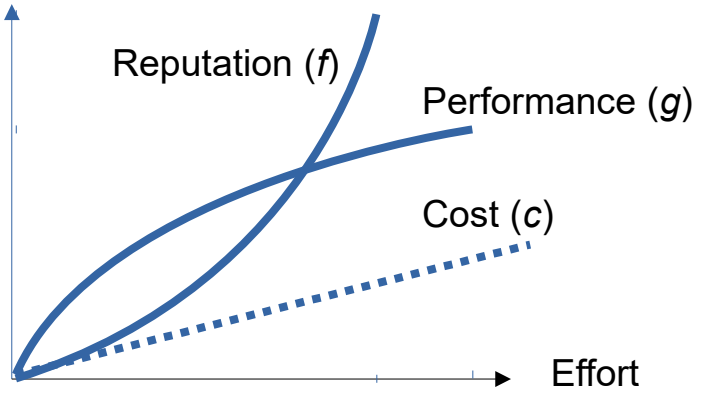
Firm F2 (h=1)

Payoff table	Institution I1 (*e* = 0)	Institution I2 (*e* = 1)
Student S1 (*a* = 0)	1, 1, 0	0.7, 0.2, 2
Student S2 (*a* = 1)	0.25, 0.25, 0	1, 0.5, 2

$f(x) = x^2$ $g(x) = \sqrt{x}$ $c(x) = 0.5x$ $p = q = 0.5$

A GAME THEORETIC MODEL

- Consider a 3rd type of player: firms.
- Firm hires *h* people from institutions focusing higher learning through say hands on programmes (*e*=1) assigning them a higher weight of 2, and the balance (*1-h*) from those with lower hands on programmes (*e*=0).
- Firm payoff: $F(e,a,h) = h*2*e + (1-h)*(1-e)$
- Student payoff: $S(e,a) = a*f(e + q(1-e)) + (1-a)*g(1-e + p*e)$
- Institution payoff: $I(e,a) = S(e,a) – c(e)$



Same two solutions as before. However, now firm resists shift to the S1,I1 configuration

Firm F1 (h=0)

Payoff table	Institution I1 (*e* = 0)	Institution I2 (*e* = 1)
Student S1 (*a* = 0)	1, 1, 1	0.7, 0.2, 0
Student S2 (*a* = 1)	0.25, 0.25, 1	1, 0.5, 0

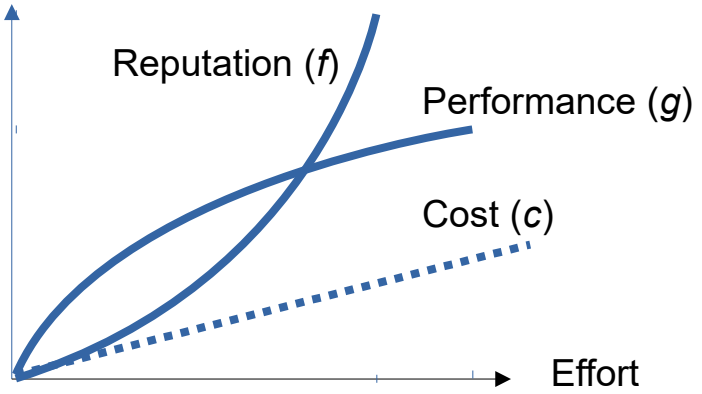
Firm F2 (h=1)

Payoff table	Institution I1 (*e* = 0)	Institution I2 (*e* = 1)
Student S1 (*a* = 0)	1, 1, 0	0.7, 0.2, 2
Student S2 (*a* = 1)	0.25, 0.25, 0	1, 0.5, 2

$f(x) = x^2$ $g(x) = \sqrt{x}$ $c(x) = 0.5x$ $p = q = 0.5$

A GAME THEORETIC MODEL

- Consider a 3rd type of player: firms.
- Firm hires *h* people from institutions focusing higher learning through say hands on programmes (*e*=1) assigning them a higher weight of 2, and the balance (*1-h*) from those with lower hands on programmes (*e*=0).
- Firm payoff: *F(e,a,h) = h*2*e + (1-h)*(1-e)*
- Student payoff:
  *S(e,a) = a*f(e + q(1-e)) + (1-a)*g(1-e + p*e)*
- Institution payoff: *I(e,a) = S(e,a) – c(e)*



Mixed strategy of Institution to make firm indifferent: e=1/3

Firm F1 (h=0)

Payoff table	Institution I1 (*e* = 0)	Institution I2 (*e* = 1)
Student S1 (*a* = 0)	1, 1, 1	0.7, 0.2, 0
Student S2 (*a* = 1)	0.25, 0.25, 1	1, 0.5, 0

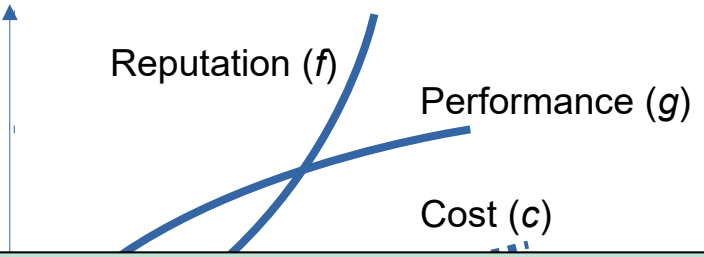
Firm F2 (h=1)

Payoff table	Institution I1 (*e* = 0)	Institution I2 (*e* = 1)
Student S1 (*a* = 0)	1, 1, 0	0.7, 0.2, 2
Student S2 (*a* = 1)	0.25, 0.25, 0	1, 0.5, 2

$f(x) = x^2$ $g(x) = \sqrt{x}$ $c(x) = 0.5x$ $p = q = 0.5$

A GAME THEORETIC MODEL

- Consider a 3rd type of player: firms.
- Firm hires *h* people from institutions focusing higher learning through say hands on programmes (*e*=1) assigning them a higher weight of 2, and the balance (*1-h*) from those with lower hands on programmes (*e*=0).
- Firm payoff: $F(e,a,h) = h*2*e + (1-h)*(1-e)$
- Student payoff: $S(e,a) = a*f(e + q(1-e)) + (1-a)*g(1-e + p*e)$
- Institution payoff: $I(e,a) = S(e,a) -$



Mixed strategy of Institution to make firm indifferent: e=1/3

Explains why firms are hiring more from private universities, who in turn are focusing more on the practical component of their programmes ?

Firm F1 (h=0)

Payoff table	Institution I1 (*e* = 0)	Institution I2 (*e* = 1)
Student S1 (*a* = 0)	1, 1, 1	0.7, 0.2, 0
Student S2 (*a* = 1)	0.25, 0.25, 1	1, 0.5, 0

Firm F2 (h=1)

Payoff table	Institution I1 (*e* = 0)	Institution I2 (*e* = 1)
Student S1 (*a* = 0)	1, 1, 0	0.7, 0.2, 2
Student S2 (*a* = 1)	0.25, 0.25, 0	1, 0.5, 2

$f(x) = x^2$ $g(x) = \sqrt{x}$ $c(x) = 0.5x$ $p = q = 0.5$

Can game theory do more than just explain?

Can game theory do more than just explain?

- **Problem statement:**
  - Our education systems works to separate the top 10-15% from the rest
  - Educators focus more and more on the top 10-15% hoping that these successful role models will prod the remaining 90% to performance. (An education version of the “trickle-down effect”)

Can game theory do more than just explain?

- **Problem statement:**
  - Our education systems works to separate the top 10-15% from the rest
  - Educators focus more and more on the top 10-15% hoping that these successful role models will prod the remaining 90% to performance. (An education version of the “trickle-down effect”)
  - Exams make this worse – as a means of feedback:
    - It is too late
    - It is too little
    - It is too negative

Can game theory do more than just explain?

- **Problem statement:**
  - Our education systems works to separate the top 10-15% from the rest
  - Educators focus more and more on the top 10-15% hoping that these successful role models will prod the remaining 90% to performance. (An education version of the “trickle-down effect”)
  - Exams make this worse – as a means of feedback:
    - It is too late
    - It is too little
    - It is too negative
  - Leading the majority of learners to psychologically drop out of the learning process (even though they may be physically participating).

Can game theory do more than just explain?

- **Problem statement:**
  - Our education systems works to separate the top 10-15% from the rest
  - Educators focus more and more on the top 10-15% hoping that these successful role models will prod the remaining 90% to performance. (An education version of the “trickle-down effect”)
  - Exams make this worse – as a means of feedback:
    - It is too late
    - It is too little
    - It is too negative
  - Leading the majority of learners to psychologically drop out of the learning process (even though they may be physically participating).
- *How do we make the majority of the learners to become willing participants of the learning process? How do ensure that they gain something substantial from it?*

Can game theory do more than just explain?

- **Problem statement:**
  - Our education systems works to separate the top 10-15% from the rest
  - Educators focus more and more on the top 10-15% hoping that these successful role models will prod the remaining 90% to performance. (An education version of the “trickle-down effect”)
  - Exams make this worse – as a means of feedback:
    - It is too late
    - It is too little
    - It is too negative
  - Leading the majority of learners to psychologically drop out of the learning process (even though they may be physically participating).
- *How do we make the majority of the learners to become willing participants of the learning process? How do ensure that they gain something substantial from it?*

Game Theory offers something for this: Mechanism Design

Mechanism design

- Mechanism needs to be designed such that:
  - It encourages the individual to **participate** in the mechanism (*individual rationality* constraint)
  - the player is better off when **revealing the truth** about his/her *type* (*incentive compatibility* constraint)

- Can we use mechanism design to change incentive structures that encourage majority of the students to participate and benefit?

Mechanism design example

- Example (© Mylspot): A 5 mark problem is given. An optional hint explains how to apply the underlying concept to solve problems like this. Student has two options:

Mechanism design example

- Example (© Mylspot): A 5 mark problem is given. An optional hint explains how to apply the underlying concept to solve problems like this. Student has two options:
  - Can attempt the problem (without hint) and get 5 marks if right, 0 if wrong.

Mechanism design example

- Example (© Mylspot): A 5 mark problem is given. An optional hint explains how to apply the underlying concept to solve problems like this. Student has two options:
  - Can attempt the problem (without hint) and get 5 marks if right, 0 if wrong.
  - Or can use the hint and get 4 marks if right, and 0 if wrong.
    (Note that students are docked only 1 mark for using the hint)

Mechanism design example

- Example (© Mylspot): A 5 mark problem is given. An optional hint explains how to apply the underlying concept to solve problems like this. Student has two options:
  - Can attempt the problem (without hint) and get 5 marks if right, 0 if wrong.
  - Or can use the hint and get 4 marks if right, and 0 if wrong.
    (Note that students are docked only 1 mark for using the hint)
  - Confident students may not use the hint, so that they can score full marks.
    However, others may take the hint, hoping to score at least 4 (instead of 0).

Mechanism design example

- Example (© Mylspot): A 5 mark problem is given. An optional hint explains how to apply the underlying concept to solve problems like this. Student has two options:
  - Can attempt the problem (without hint) and get 5 marks if right, 0 if wrong.
  - Or can use the hint and get 4 marks if right, and 0 if wrong.
    (Note that students are docked only 1 mark for using the hint)
  - Confident students may not use the hint, so that they can score full marks.
    However, others may take the hint, hoping to score at least 4 (instead of 0).
  - Will this mechanism induce truth revelation of the “type” of the learner?

Mechanism design example

- Example (© Mylspot): A 5 mark problem is given. An optional hint explains how to apply the underlying concept to solve problems like this. Student has two options:
  - Can attempt the problem (without hint) and get 5 marks if right, 0 if wrong.
  - Or can use the hint and get 4 marks if right, and 0 if wrong.
    (Note that students are docked only 1 mark for using the hint)
  - Confident students may not use the hint, so that they can score full marks. However, others may take the hint, hoping to score at least 4 (instead of 0).
  - Will this mechanism induce truth revelation of the "type" of the learner?
- If the learner's ability is *a, p(a)* and *q(a) are* monotonic functions that give the probability of answering correctly without and with the hint respectively. Then truth revelation happens when *4q(a) > 5p(a)*. Top learners with *p(a)=1* will not take the hint. However, those with *a* such that *p(a)/q(a) < 4/5,* will opt for the hint.

Mechanism design example

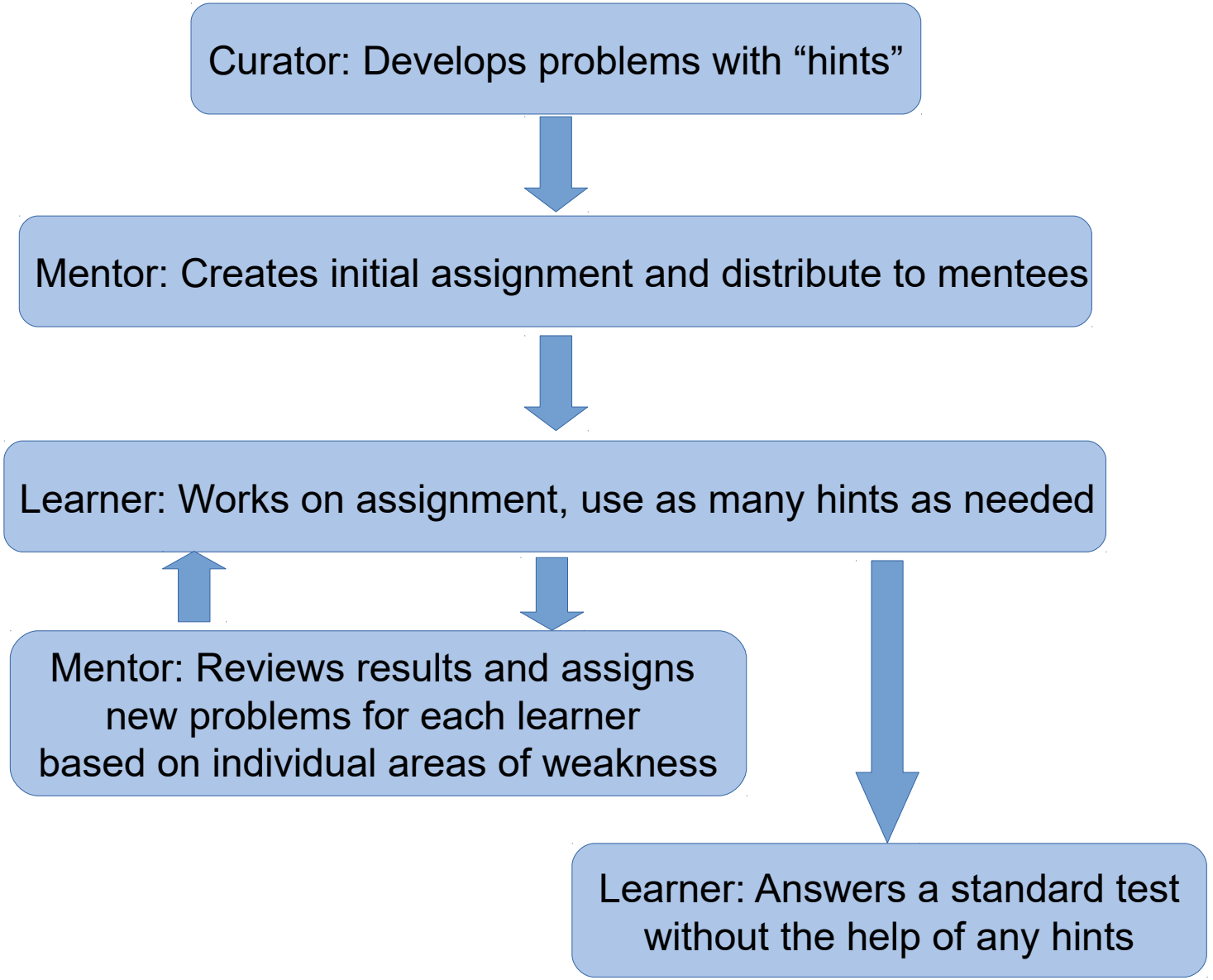
- Example (© Mylspot): A 5 mark problem is given. An optional hint explains how to apply the underlying concept to solve problems like this. Student has two options:
  - Can attempt the problem (without hint) and get 5 marks if right, 0 if wrong.
  - Or can use the hint and get 4 marks if right, and 0 if wrong.
    (Note that students are docked only 1 mark for using the hint)
  - Confident students may not use the hint, so that they can score full marks. However, others may take the hint, hoping to score at least 4 (instead of 0).
  - Will this mechanism induce truth revelation of the "type" of the learner?
- If the learner's ability is *a, p(a)* and *q(a) are* monotonic functions that give the probability of answering correctly without and with the hint respectively. Then truth revelation happens when $4q(a) > 5p(a)$. Top learners with $p(a)=1$ will not take the hint. However, those with *a* such that $p(a)/q(a) < 4/5$, will opt for the hint.
- If in the population of students, 60% get it right without a hint, but 90% get it right with the hint, then the "average" student has $p(a)=0.6$ and $q(a)=0.9$ with $p(a)/q(a) = 0.67 < 4/5$. So, the average student takes help of the hint.

Mechanism design example

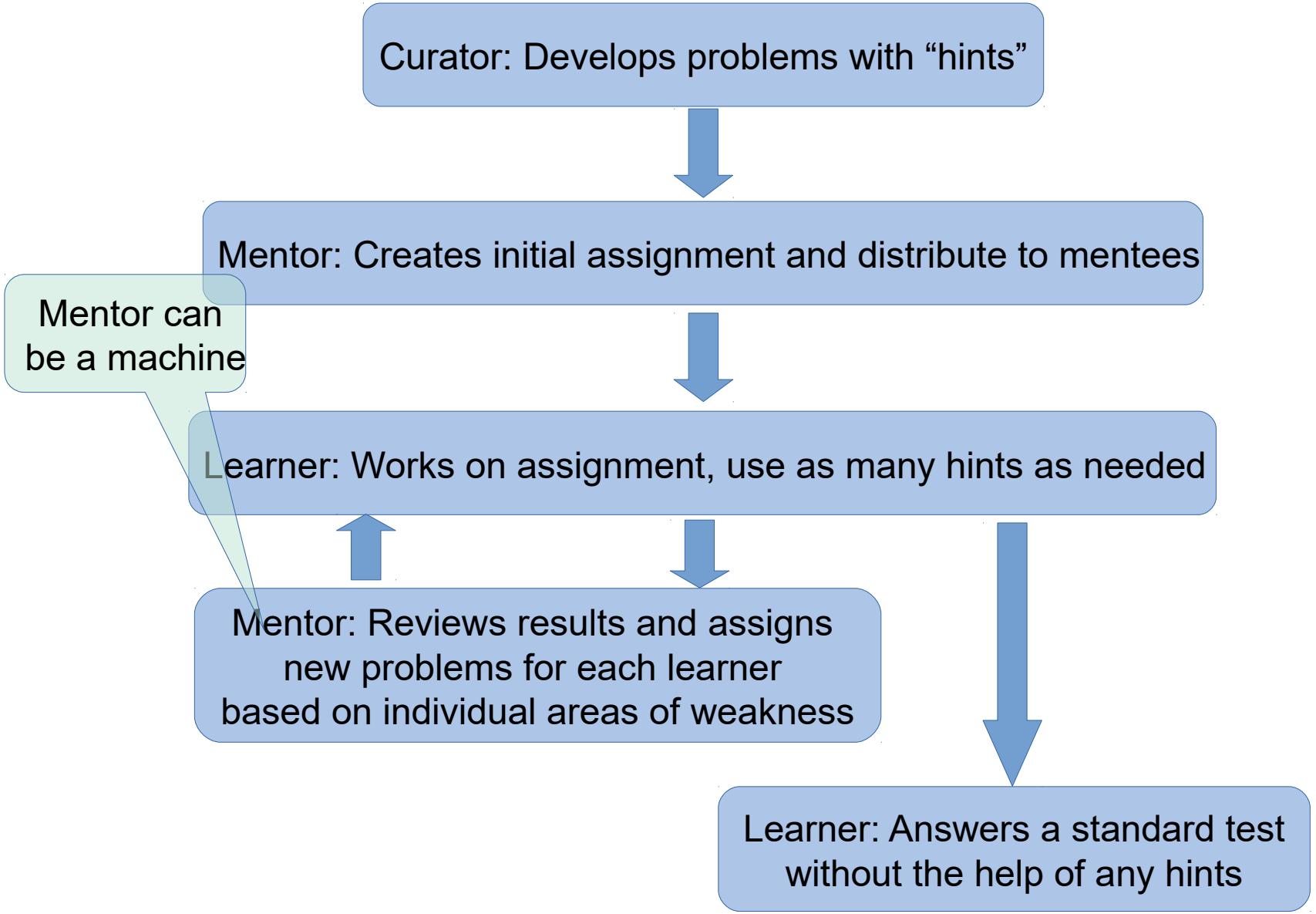
- Example (© Mylspot): A 5 mark problem is given. An optional hint explains how to apply the underlying concept to solve problems like this. Student has two options:
  - Can attempt the problem (without hint) and get 5 marks if right, 0 if wrong.
  - Or can use the hint and get 4 marks if right, and 0 if wrong.
    (Note that students are docked only 1 mark for using the hint)
  - Confident students may not use the hint, so that they can score full marks. However, others may take the hint, hoping to score at least 4 (instead of 0).
  - Will this mechanism induce truth revelation of the "type" of the learner?
- If the learner's ability is *a, p(a)* and *q(a) are* monotonic functions that give the probability of answering correctly without and with the hint respectively. Then truth revelation happens when $4q(a) > 5p(a)$. Top learners with $p(a)=1$ will not take the hint. However, those with *a* such that $p(a)/q(a) < 4/5$, will opt for the hint.
- If in the population of students, 60% get it right without a hint, but 90% get it right with the hint, then the "average" student has $p(a)=0.6$ and $q(a)=0.9$ with $p(a)/q(a) = 0.67 < 4/5$. So, the average student takes help of the hint.

Educator has gained information about the student's knowledge (or confidence). Can use this to suggest further learning or problems (personalised learning)

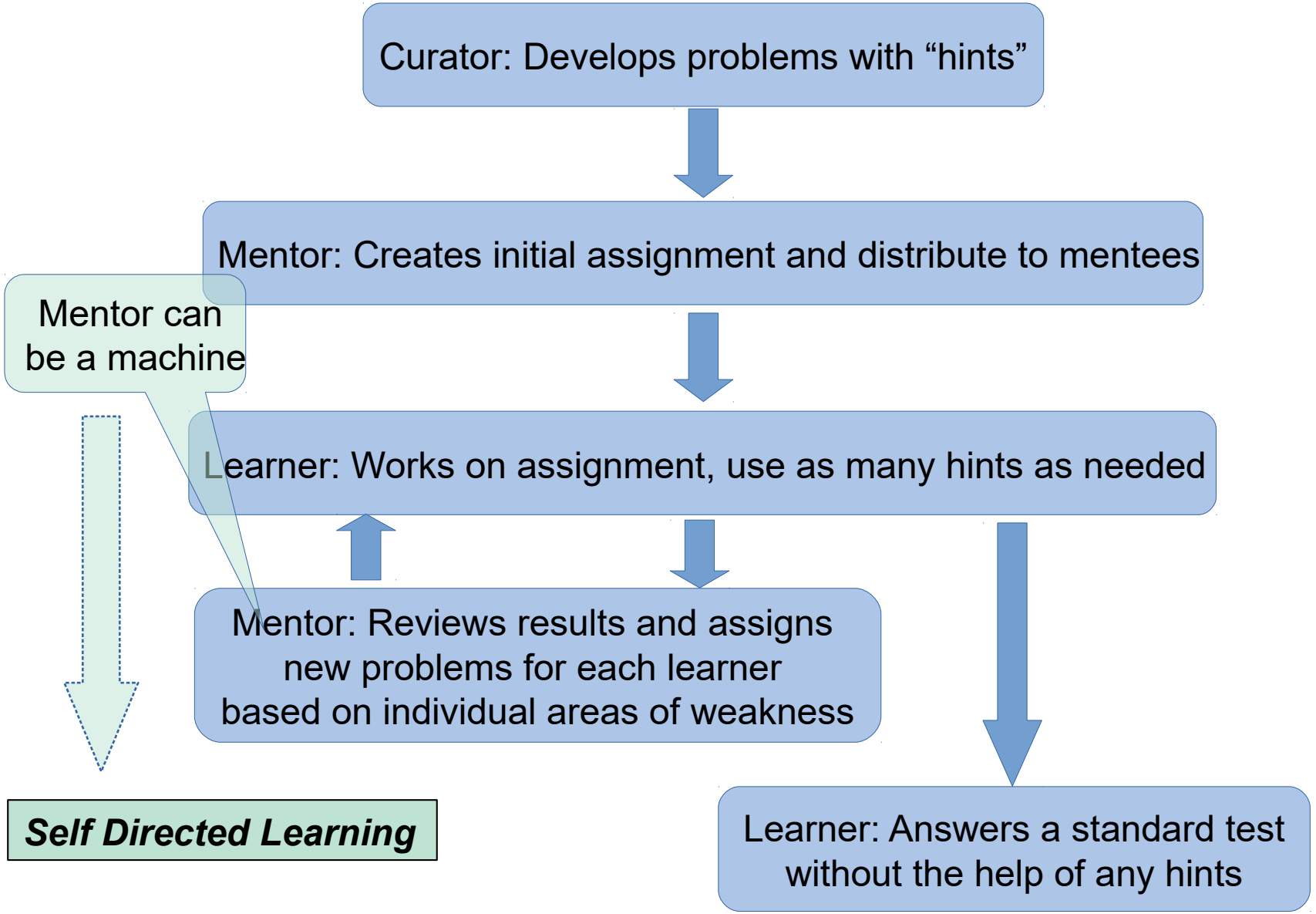
Mylspot personalised learning



Mylspot personalised learning



Mylspot personalised learning



Summary: Using game theory for pedagogy

- Game Theory is not the same as “gamification”:
  - In gamification, education content is presented in the form of a game
    - Cast content as an action-adventure, role-playing, simulation, strategy game
    - Badges and “level-up” provide feedback while motivating participation.
  - Gamification has benefits: it diverts part of the time spent on games to the useful purpose of education
- Game Theory helps:
  - Explain adverse scenarios and situations that arise due to interaction between the actions of multiple stakeholders involved in the field of education
  - Identify corrective steps that may alter the circumstances that govern the scenario or situation, thereby leading to new incentives for the stakeholders to act differently
  - Design new pedagogy mechanisms that increase learner participation and benefits

We need more evidence based policy research in education

Thank You !