

Gut Instinct

Creating Scientific Theories with Online Learners

UC San Diego

The Design Lab

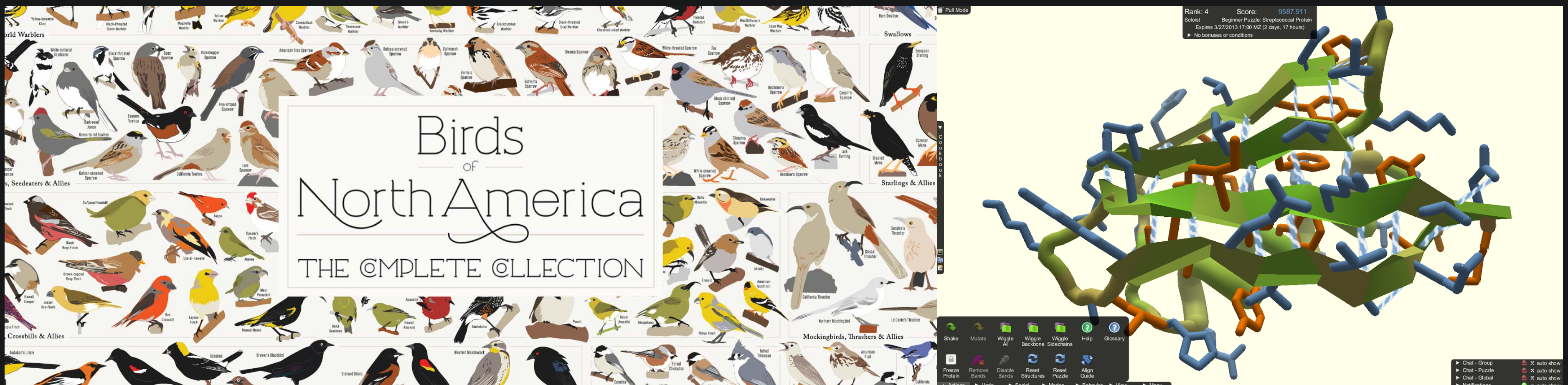
Vineet Pandey
Scott Klemmer

 @GutInstinctUCSD



Amnon Amir
Justine Debelius
Embriette R. Hyde
Tomasz Kosciolk
Rob Knight

Citizen scientists have successfully solved expert-defined problems as "sensors" or "algorithms"



Tracking bird migration
eBird [Sullivan et al. 2009]

Folding proteins
Foldit [Cooper et al. 2010]

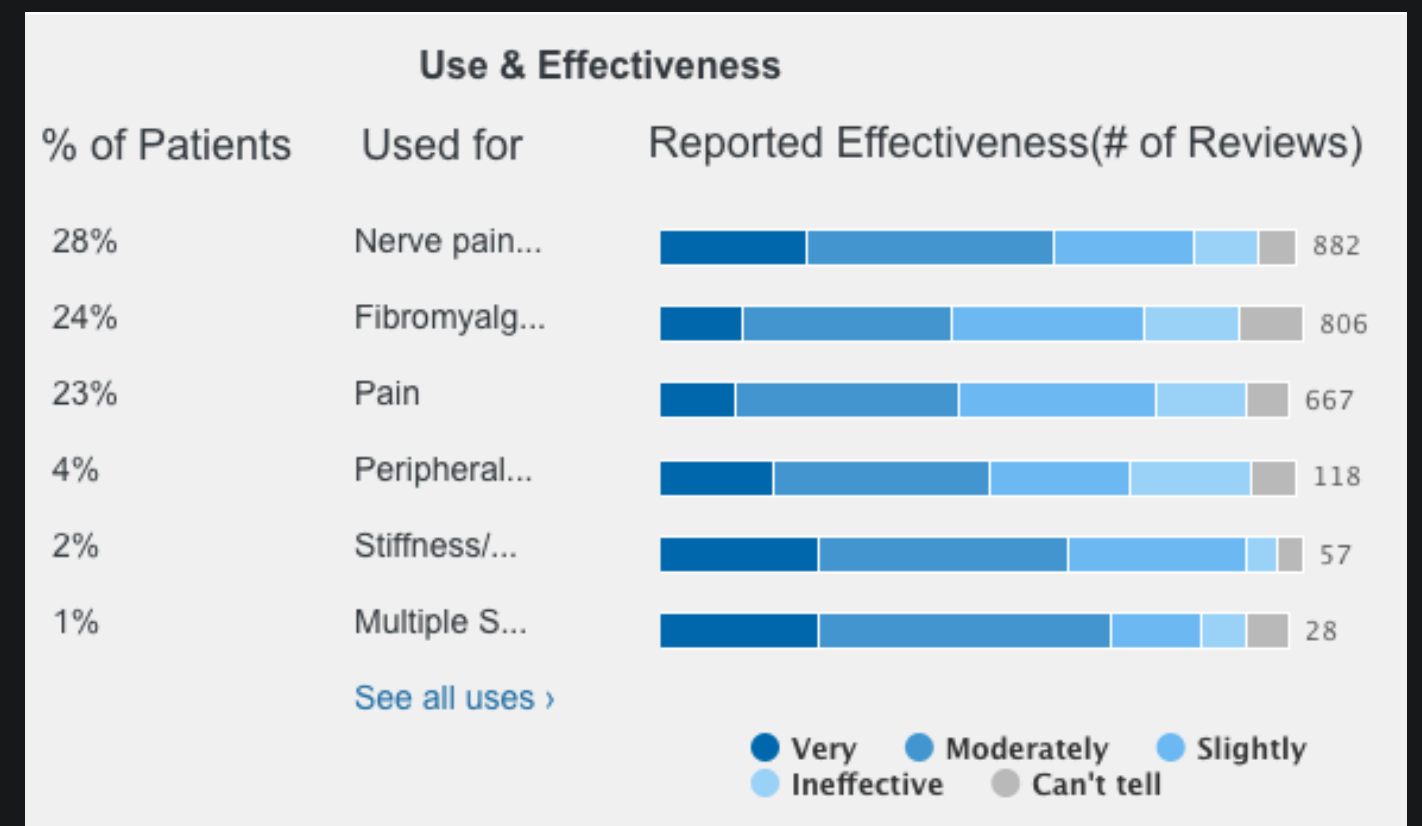
Powerful ideas emerge when people combine data with personal insights



Genomics
23andme



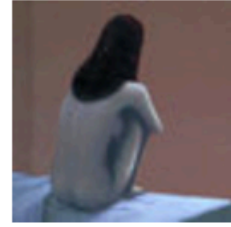
Microbiome
American Gut



Medicine effects
Patientslikeme



[A Baffling Brain Defect Is Linked to Gut Bacteria, Scientists Say](#)



VOICES
[A Suicide Therapist's Secret Past](#)

PAID POST: TROPICANA
[Why Making Orange Juice Is Not as Easy as You Think](#)



PHYS ED
[Noisy Knees? Arthritis May Be in Your Future](#)



[Why Everything We Know About Salt May Be Wrong](#)

A Baffling Brain Defect Is Linked to Gut Bacteria, Scientists Say

By GINA KOLATA MAY 10, 2017



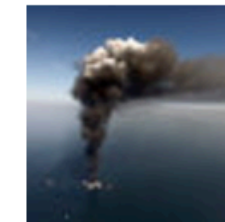
RELATED COVERAGE



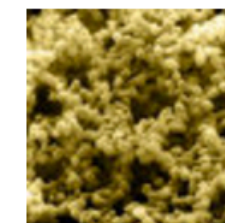
THE NEW HEALTH CARE
[Exciting Microbe Research? Temper That Giddy Feeling in Your Gut](#) MARCH 6, 2017



[Say Hello to the 100 Trillion Bacteria That Make Up Your Microbiome](#) MAY 15, 2013



[Scientists Urge National Initiative on Microbiomes](#) OCT. 28, 2015



TAKE A NUMBER
[40 Trillion Bacteria on and in Us? Fewer Than We Thought.](#) FEB. 15, 2016

Scientists' questions can miss contextual insights

Do you think you'd perform better in a sprint or in a longer distance race?

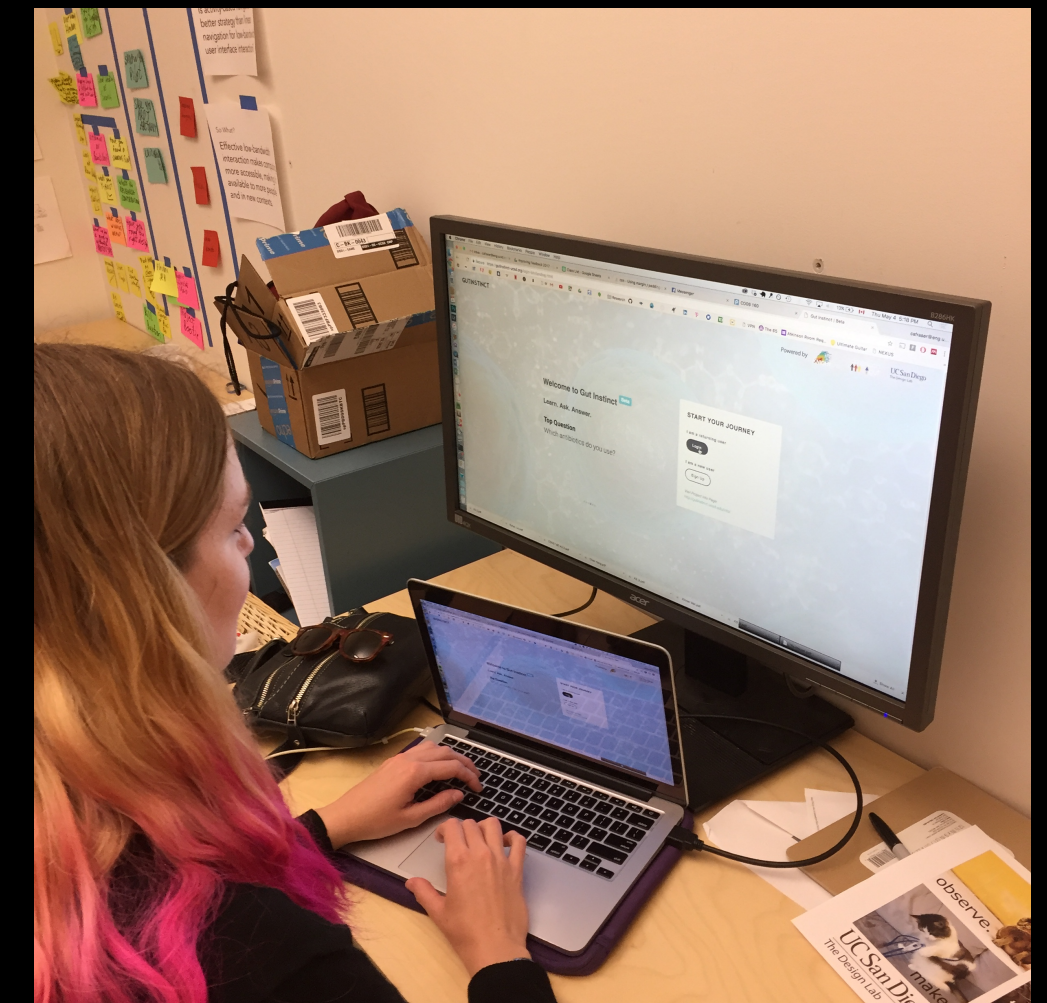
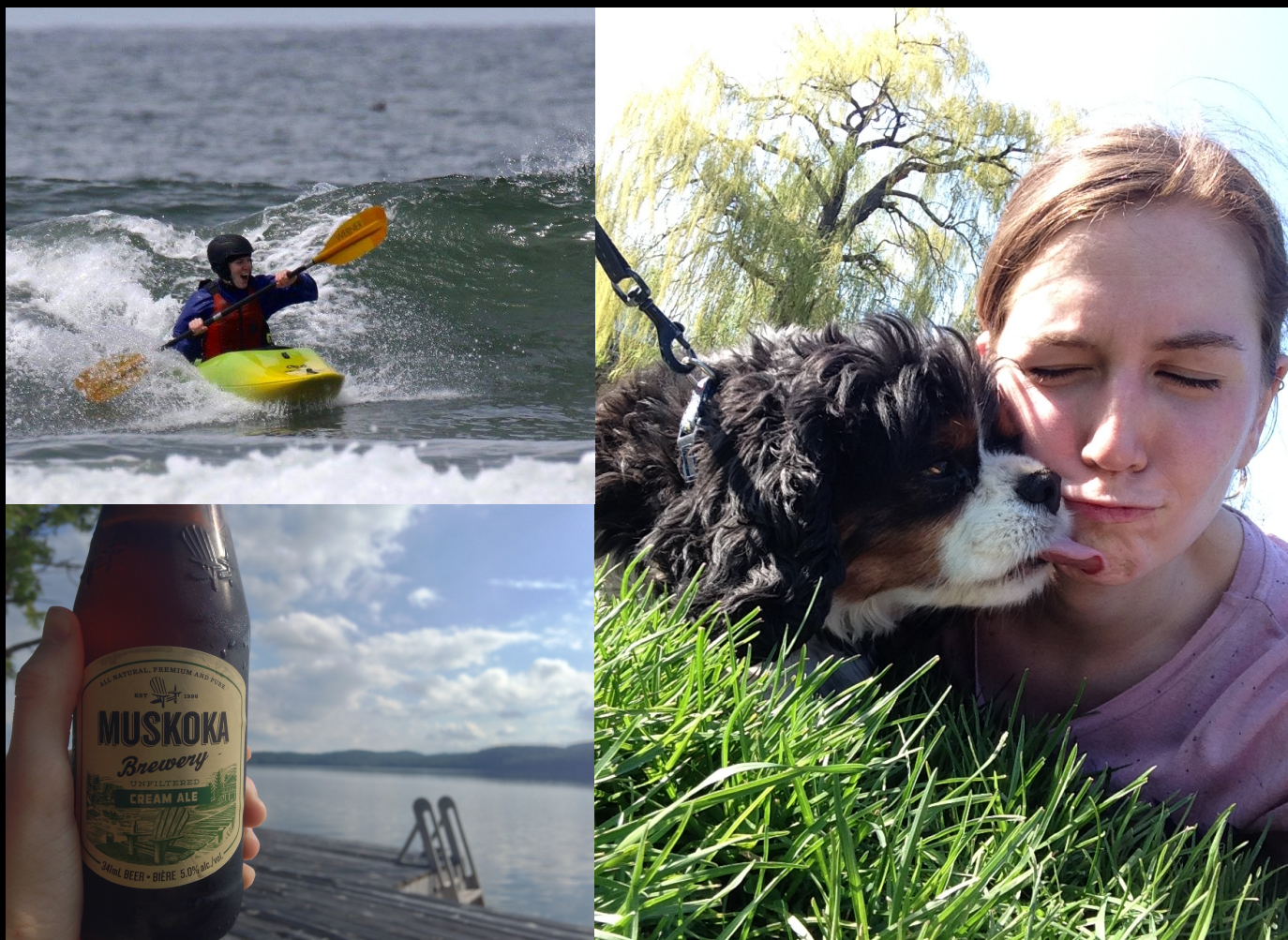
- Sprint race
- Longer distance race
- Both - I'm like the wind
- Neither

How might people's situated knowledge supplement ivory tower science?

**Please chew with
your mouth shut.**

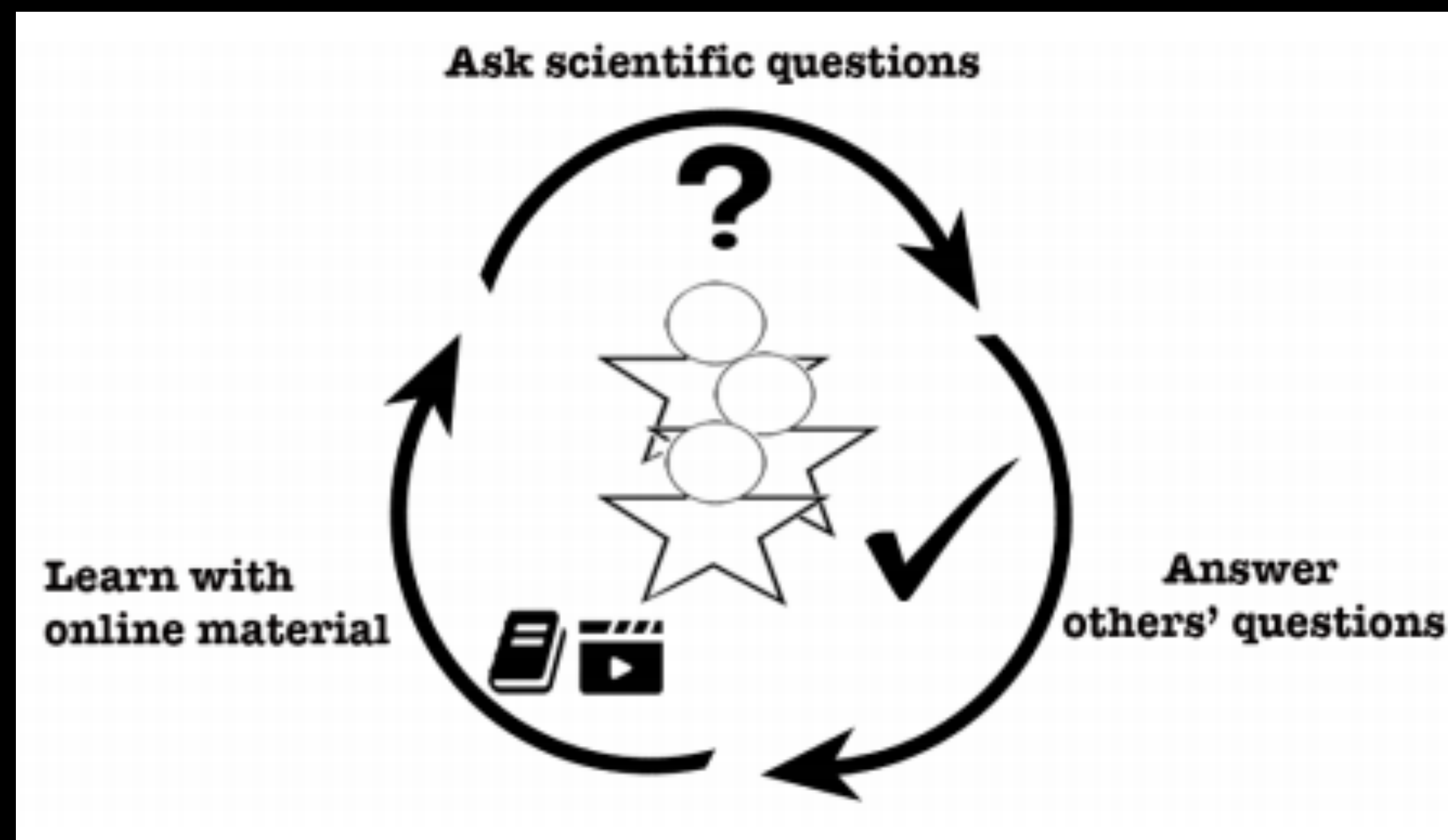
Can curious people perform scientific work while meeting their needs?

Contribute scientific hypotheses based on lifestyle



Use scientific knowledge to identify lifestyle choices

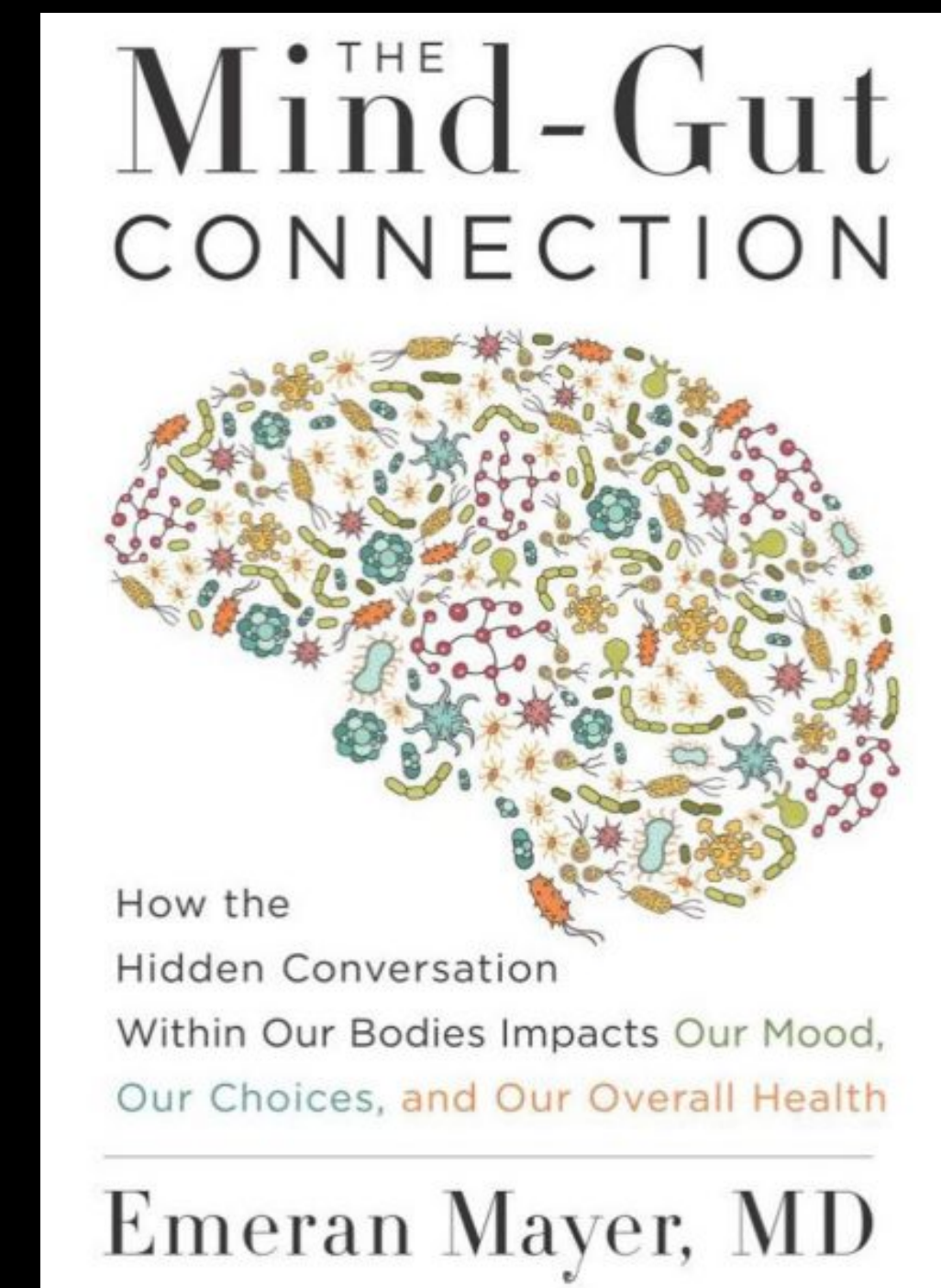
Gut Instinct integrates learning and asking questions about nascent science



gutinstinct.ucsd.edu

Understanding the human microbiome requires insights into people's lifestyles

- Microbiome = Collection of all microbes and their genes in our body
- Extremely personal; shows drastic effects on health
Men infected with *Toxoplasma gondii* tend to be rule-breakers, while infected women are more sociable [Flegr et al. 1996]



**Results: 10 of 29
participants'
questions *matched*
researchers' questions**

(we think this is good)

Do you drink soylent regularly?

Do you eat red meat so often?

Do you use the treadmill at the gym?

**Do you take any meal replacements
such as protein powders?**

Do you smoke?

Do you poop regularly?

Were you not breast fed as a child?

Are you regular got drunk?

**Do you exercise regularly or have
enough physical activities?**

Do you sleep at least 7-8 hours a night?

Have you quit smoking in the past?

Do you eat hot (spicy) food often?

Did you ever switch from a meat based
diet to a vegan diet or vice versa?

Do you eat meals while working?

Do you eat raw meat?

Do you smoke weed ?

Do you just eat 1-2 meals a day ?

Do you eat probiotic yogurt?

Do you think you have a belly?

Do you eat probiotic yogurt?

Do you have really bad smelling poop?

Do you eat blueberries regularly?

Do you drink coffee?

Do you often feel fatigued?

Are you a morning person ?

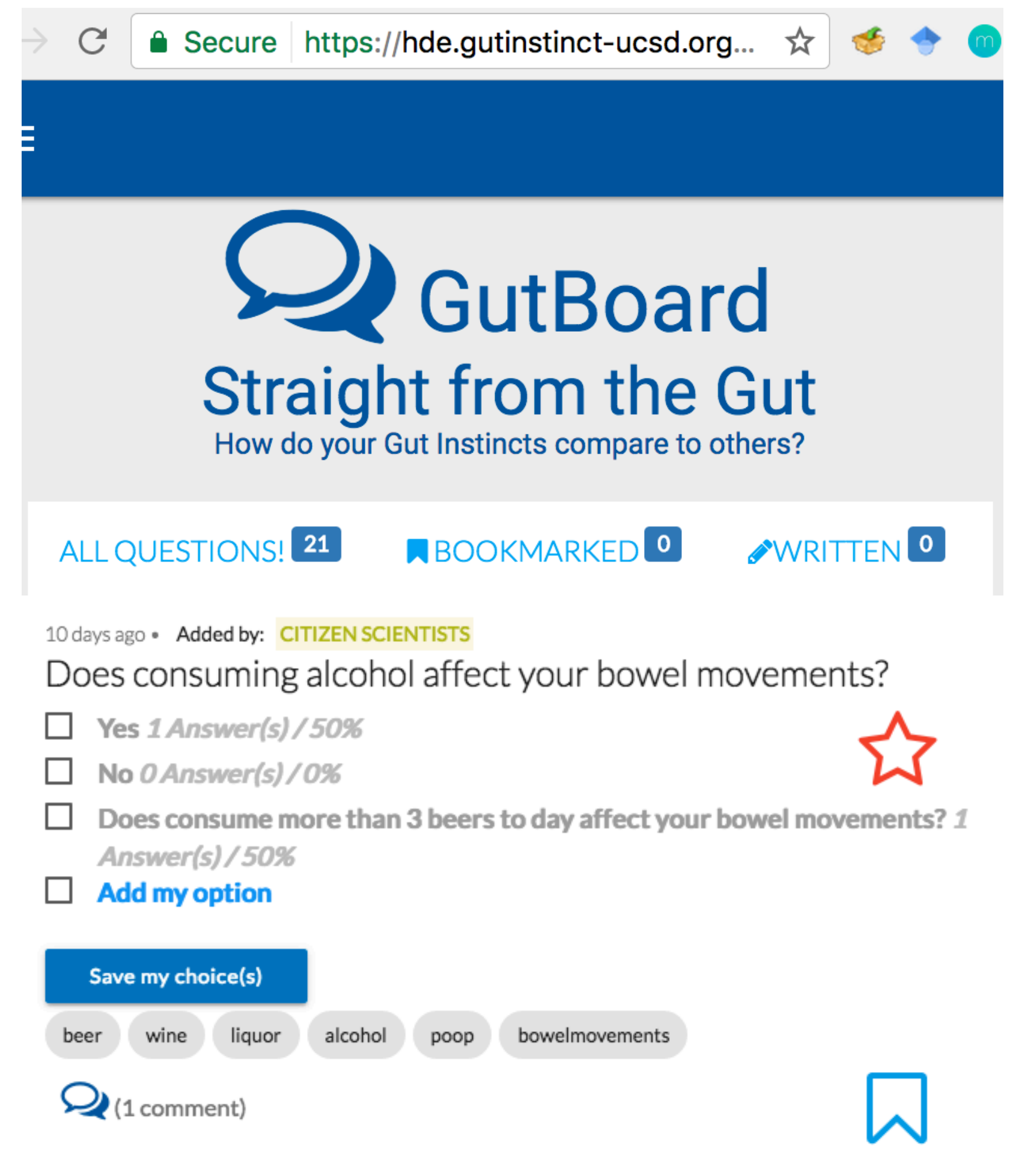
Do you follow a sleep cycle?

Do you use antibacterial soap?

Do you wash your hands everytime you
use the bathroom?

Do you follow a specific diet?

Step 1: Answer questions created by other participants



The screenshot shows a web browser window with the URL <https://hde.gutinstinct-ucsd.org...>. The page features the GutBoard logo and the text "Straight from the Gut" and "How do your Gut Instincts compare to others?". Below the header, there are navigation links: "ALL QUESTIONS! 21", "BOOKMARKED 0", and "WRITTEN 0". The main content area displays a question: "Does consuming alcohol affect your bowel movements?". The question is marked as "Added by: CITIZEN SCIENTISTS" and "10 days ago". The question has three options: "Yes 1 Answer(s) / 50%", "No 0 Answer(s) / 0%", and "Does consume more than 3 beers to day affect your bowel movements? 1 Answer(s) / 50%". There is a red star icon next to the "No" option. Below the question, there is a "Save my choice(s)" button and a list of tags: "beer", "wine", "liquor", "alcohol", "poop", and "bowelmovements". There is also a comment icon with "(1 comment)" and a bookmark icon.

Step 1a: Answer follow-up questions created by other participants

Dive deeper with these follow-up questions!

What type of alcoholic drinks (ex wine, beer, liquor, mixed with sugar) affect your bowel movements?

- wine
- beer
- liquor
- sugary mixed drinks
- [Add my option](#)

Save my choice(s)

Skip

How many drinks does it take to notice a difference in your bowel movements?

- 1-2
- 3-4
- 5+
- [Add my option](#)

Save my choice(s)

Skip

Step 2: Ask questions



The screenshot shows a web browser window with the URL [https://gutinstinct-ucsd.org/...](https://gutinstinct-ucsd.org/). The page features the GutBoard logo, which consists of two overlapping speech bubbles, and the text "GutBoard Straight from the Gut". Below this, a light blue box contains the heading "Add your Gut Instinct here!" followed by a list of seven steps:

- Step 1: Add top-level question and options
- Step 2: Add follow-up question and options
- Step 3: Add more follow up questions
- Step 4: Start a discussion
- Step 5: Add tags
- Step 6: Add a URL/ Attach a file!
- Step 7: Review and submit

Step 2a: Ask questions

Add your Gut Instinct here!

Step 1: Add top-level question and options

Think of interesting questions that are personally relevant to you! Many crazy ideas have led to amazing discoveries, esp for gut microbiome - so don't shy away!

sample: How frequently do you eat probiotic yogurt?

Option 1:

enter your option here

ADD MORE OPTIONS

SAVE&NEXT

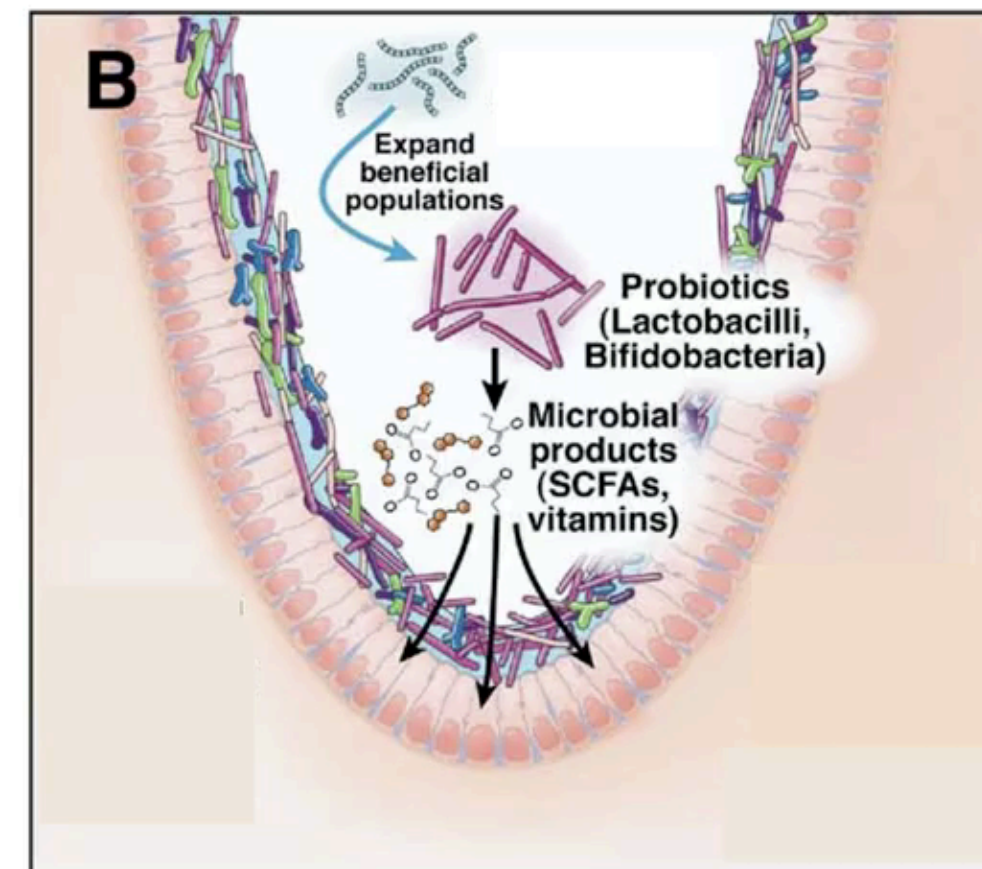
Step 3: Learn about the scientific domain

The screenshot shows a web browser at the URL <https://hde.gutinstinct-ucsd.org/topics>. The page features a blue navigation bar with links for 'Confused?', 'Add your question!', 'Topics', 'Guide', 'GutBoard', and 'Notifications'. The main heading is 'Follow Your Gut' with a subtext 'Choose among following topics to understand your gut!'. Below this are four topic cards: 'Genetics' (DNA helix), 'Physiology' (human torso), 'Probiotics' (green capsules), and 'Introduction' (lightbulb icon).

Step 3a: Learn about #antibiotics



Photo credit: Creative Commons License



Preidis and Versalovic 2009, Gastroenterology

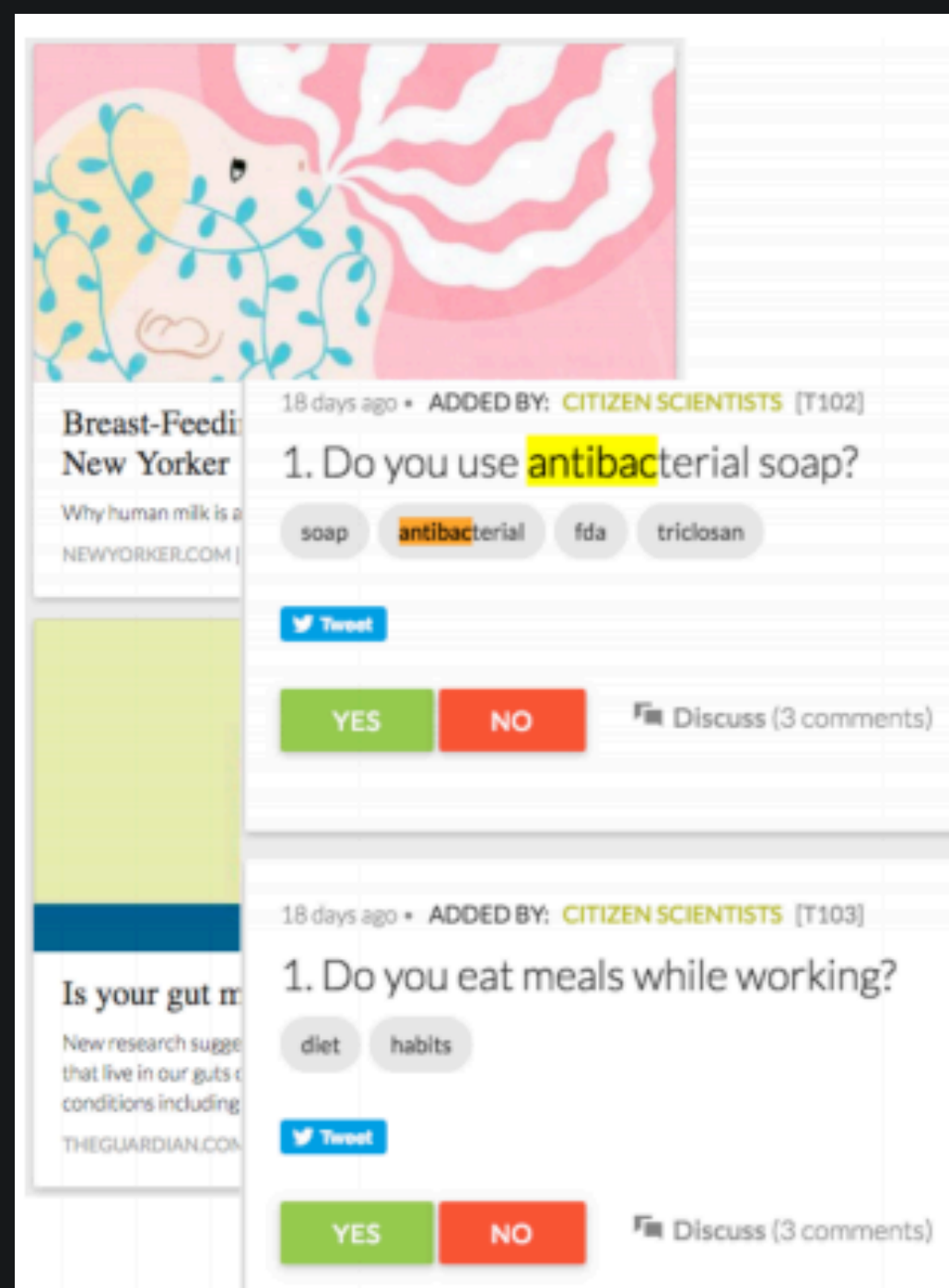
Hypotheses for Dual-objective online learning systems

H1 Learning improves quality of work
on relevant problems.

H2 Working on relevant real-world
problems improves learning.

Between-subjects experiment (N=44) w/ 3 conditions; Lab study followed by 3-day use

Between-subjects experiment (N=44) w/ 3 conditions: *Contribute, Learn, & Combined*



(1) Contribute

Between-subjects experiment (N=44) w/ 3 conditions: *Contribute, Learn, & Combined*

The screenshot shows a 'Contribute' interface with two survey questions. The first question is '1. Do you use antibacterial soap?' with tags 'soap', 'antibacterial', 'fda', and 'triclosan'. It has 'YES' and 'NO' buttons and a 'Discuss (3 comments)' link. The second question is '1. Do you eat meals while working?' with tags 'diet' and 'habits'. It also has 'YES' and 'NO' buttons and a 'Discuss (3 comments)' link. Both questions are attributed to 'CITIZEN SCIENTISTS' and include a 'Tweet' button.

(1) Contribute

The screenshot shows a 'Learn' interface. At the top, it says '#diet' and provides a link to explore more topics. Below is a video player showing a scatter plot of PC2 (8.6%) from UniFrac distance for US, Malawians, and Amerindians. A quiz question asks 'Which of these is not true? Germ-free mice have:' with options: 'Similar immune activity to normal mice', 'Reduced immune activity', 'Fewer immune cells', and 'Increased rates of infection'. The user has attempted 4 times and is incorrect. Below the video, another question asks 'Does short-term diet... Leaky gut refers to:' with options: 'Diarrhea after consumption of certain synthetic fats, such as olestra', 'Short-chain fatty acids getting into the gut epithelium', 'Bacteria passing across the gut epithelial membrane', and 'Food passing across the gut into the bloodstream more than it should'. The user has attempted 3 times and is correct. Both questions have 'SUBMIT' buttons and 'Click here to discuss about this question' links.

(2) Learn

Between-subjects experiment (N=44) w/ 3 conditions: *Contribute, Learn, & Combined*

Breast-Feeding New Yorker
Why human milk is a
NEWYORKER.COM |

18 days ago • ADDED BY: CITIZEN SCIENTISTS [T102]
1. Do you use antibacterial soap?
soap antibacterial fda triclosan
TWEET
YES NO Discuss (3 comments)

18 days ago • ADDED BY: CITIZEN SCIENTISTS [T103]
1. Do you eat meals while working?
diet habits
TWEET
YES NO Discuss (3 comments)

(1) Contribute

#diet
#diet is one of many topics. You can explore more topics from the main topics page.

1:04 / 3:16

Which of these is not true? Germ-free mice have:
Incorrect. Attempted 4 times.
 Similar immune activity to normal mice
 Reduced immune activity
 Fewer immune cells
 Increased rates of infection
SUBMIT
[Click here to discuss about this question](#)

Does short-term diet
Correct! Rapid changes in short microbiome. Consuming only for the video for more.
 Yes, but it cannot cause dra
 Yes, it can cause huge swing
 No, it does not have influen
 Researchers just don't know
SUBMIT

Leaky gut refers to:
Correct. Attempted 3 times.
 Diarrhea after consumption of certain synthetic fats, such as olestra
 Short-chain fatty acids getting into the gut epithelium
 Bacteria passing across the gut epithelial membrane
 Food passing across the gut into the bloodstream more than it should
SUBMIT
[Click here to discuss about this question](#)

(2) Learn

#diet
#diet is one of many topics. You can explore more topics from the main topics page.

1:04 / 3:16

18 days ago • ADDED BY: CITIZEN SCIENTISTS [T102]
1. Do you use antibacterial soap?
soap antibacterial fda triclosan
TWEET
YES NO Discuss (3 comments)

18 days ago • ADDED BY: CITIZEN SCIENTISTS [T103]
1. Do you eat meals while working?
diet habits
TWEET
YES NO Discuss (3 comments)

(3) Combined

Measures

- Questions: Novelty and usefulness
(measured by blind, independent raters)
- Learning: Score on summative test

**Results: 10 of 29
participants'
questions *match official
American Gut survey***

(we think this is good)

Do you drink soylent regularly?

Do you eat red meat so often?

Do you use the treadmill at the gym?

**Do you take any meal replacements
such as protein powders?**

Do you smoke?

Do you poop regularly?

Were you not breast fed as a child?

Are you regular got drunk?

**Do you exercise regularly or have
enough physical activities?**

Do you sleep at least 7-8 hours a night?

Have you quit smoking in the past?

Do you eat hot (spicy) food often?

Did you ever switch from a meat based
diet to a vegan diet or vice versa?

Do you eat meals while working?

Do you eat raw meat?

Do you smoke weed ?

Do you just eat 1-2 meals a day ?

Do you eat probiotic yogurt?

Do you think you have a belly?

Do you eat probiotic yogurt?

Do you have really bad smelling poop?

Do you eat blueberries regularly?

Do you drink coffee?

Do you often feel fatigued?

Are you a morning person ?

Do you follow a sleep cycle?

Do you use antibacterial soap?

Do you wash your hands everytime you
use the bathroom?

Do you follow a specific diet?

Challenge: Gut Instinct questions are not framed as hypotheses

1. Do you drink soylent regularly?

diet soylent

Tweet

YES NO Discuss (1 comment)

12% said "Yes" and 88% said "No"

2. If so, have you noticed any specific changes in your lifestyle? For example, do you get hungry more often or do you feel more energetic?

Score: 5/6

(Novelty: 2, Usefulness: 3)

1. Do you think you have a belly?

exercise

Tweet

YES NO Discuss (2 comments)

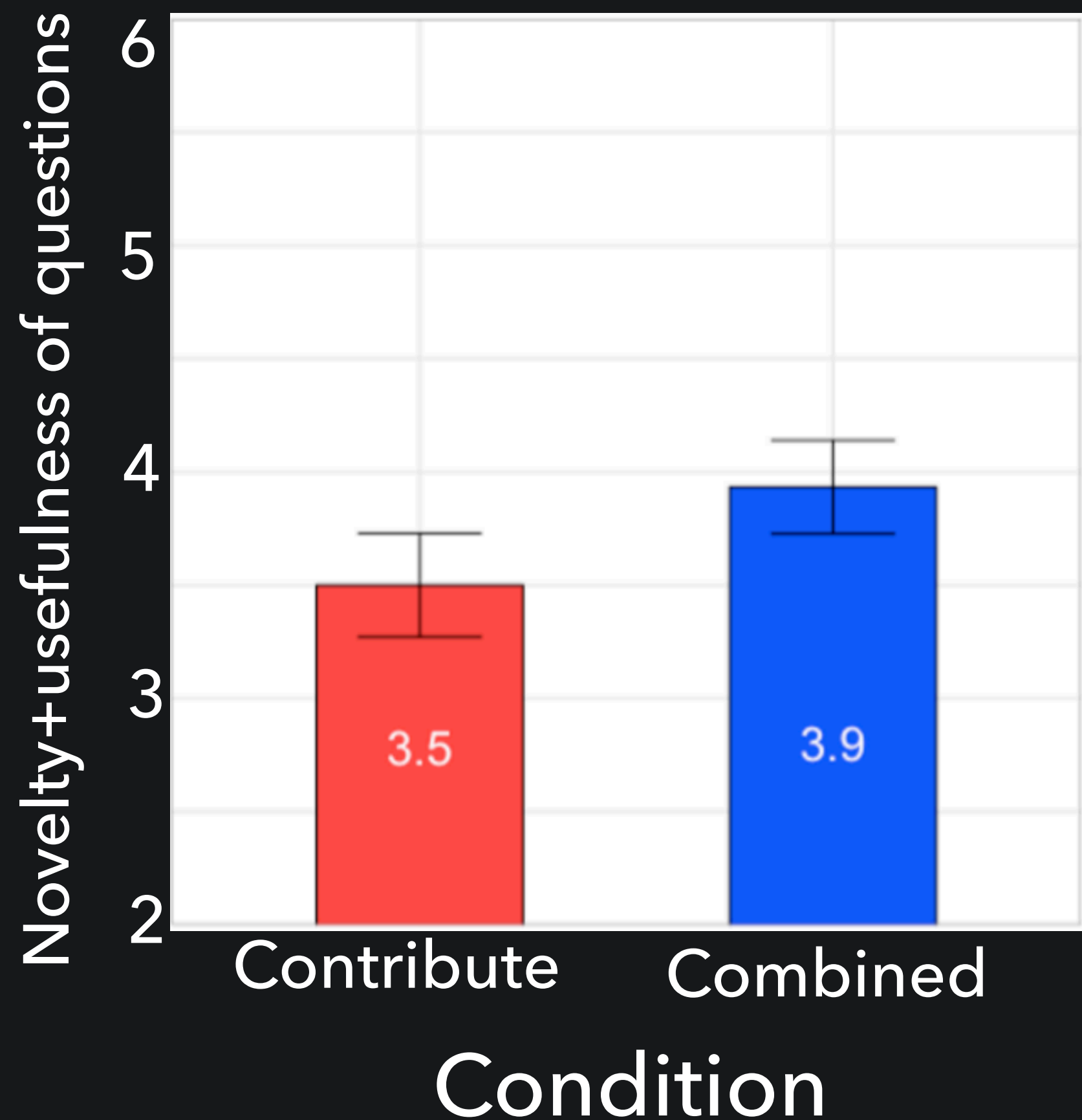
64% said "Yes" and 36% said "No"

2. What steps do you take to get a flatter stomach?

Score: 2/6

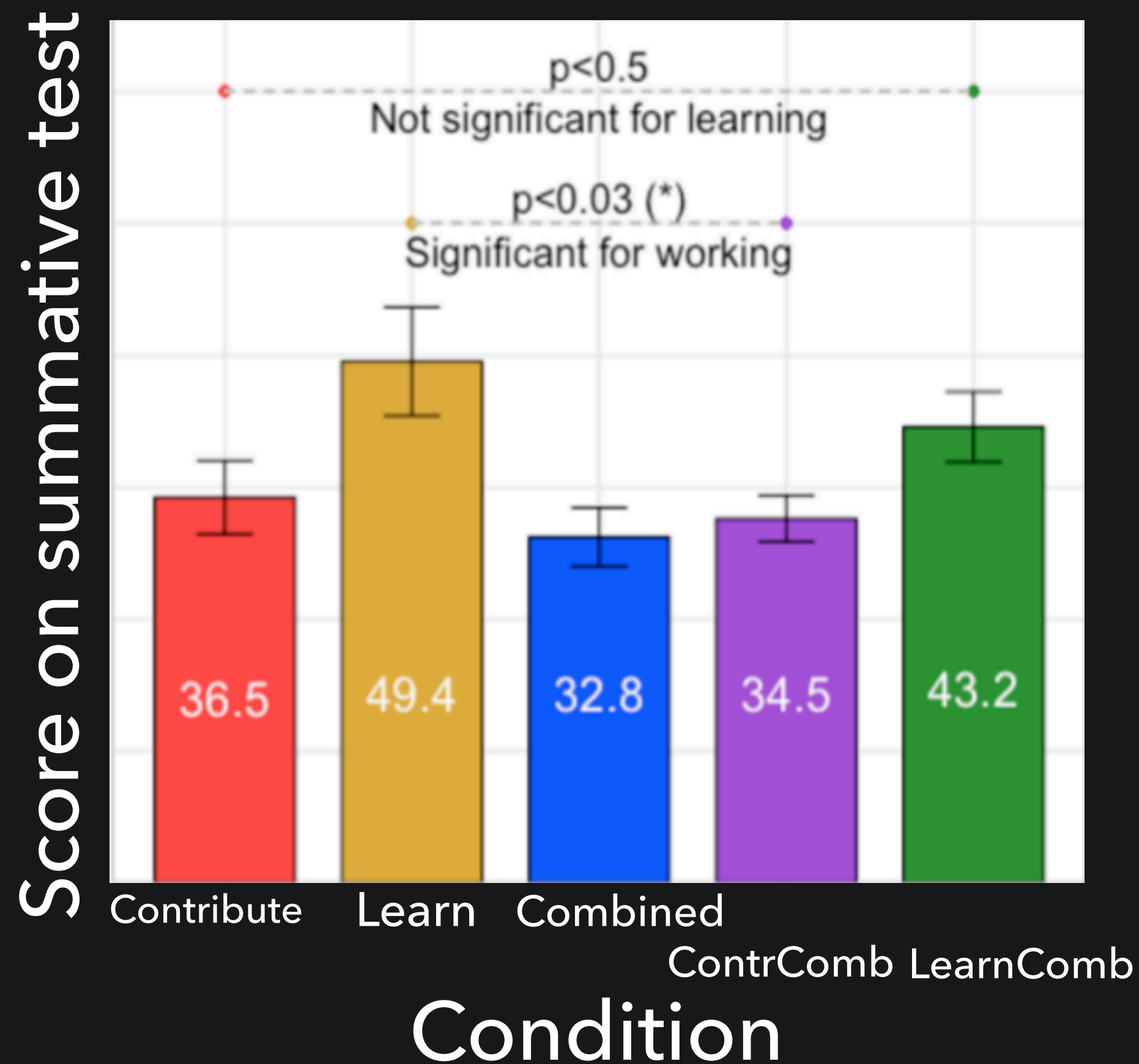
(Novelty: 1, Usefulness: 1)

Results: H1. Did learning improve quality of questions? No.



Participants in Contribute and Combined conditions created questions of similar quality

Results: H2. Did asking questions improve learning scores? No.



Participants in Learn condition performed the best on a summative test.

Learning did not show a significant effect on score but working did.

Combined condition did not perform better because..

- Multiple criteria of success
- Cognitive overload of multiple tasks
- Short "incubation" time for "scientists"
- Personalized learning and need for feedback
- ...

Systems with two objectives often achieve one but not the other



Duolingo

Language learning + translation

[Hacker 2014]



Have your cake

Language learning + translation

[Culbertson et al. 2017]



Is this galaxy likely to have high rates of star formation? T F

Crowdclass

Decision-trees + galaxy classification

[Lee et al. 2016]

Dual-objective online learning systems: Promise and challenges

- Learning & working
 - Integrate objectives and provide clear criteria of success
 - Task-specific scaffolding (aka how to generate good hypotheses)
- Make learning & work personally relevant
 - Working with intrinsically motivated participants



From the gut microbiome... to where? Calling out to potential collaborators..



gutinstinct.ucsd.edu
americangut.org



Cultural
psychology



Transcranial
direct-current
stimulation

References

- [Sullivan et al. 2009] **eBird**: A citizen-based bird observation network in the biological sciences. Brian L. Sullivan *, Christopher L. Wood, Marshall J. Iliff, Rick E. Bonney, Daniel Fink, Steve Kelling.
- [Cooper et al. 2010] Predicting protein structures with a multiplayer online game.
- [Flegr et al. 1996] Induction of changes in human behaviour by the parasitic protozoan *Toxoplasma gondii*.
- [Hacker 2014] Severin Benedict Hans Hacker. 2014. Duolingo: Learning a Language while Translating the Web. Ph.D Dissertation.
- [Culbertson et al. 2017] Gabriel Culbertson, Solace Shen, Erik Andersen, Malte Jung. Have your Cake and Eat it Too: Foreign Language Learning with a Crowdsourced Video Captioning System. CSCW 2017.
- [Lee et al. 2016] Doris Lee, Joanne Lo, Moonhyok Kim, Eric Paulos. Designing classification-based citizen science learning modules. HCOMP 2016

Extra slides