Remote laboratories for digital electronics: an overview

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Introductory note

This presentation reuses slides from:

- A joint keynote (together with Prof. Javier García Zubía, University of Deusto, Spain) @ 18th Remote Engineering and Virtual Instrumentation (REV), 2021
- A series of remote presentations made during the COVID-19 lockdown

Plus new slides from updated, recent and other sources, including:

- LabsLand® website
- PhD Thesis, Aitor Villar Martínez, University of Deusto, Spain, Jan. 2023
- PhD Thesis, Raul Cordeiro, NOVA Lisboa, Portugal, Dec. 2018

Outline

- History of remote laboratories (disambiguation)
  - The COVID-19 lockdown
- Teaching & Learning methodologies associated with Non-Traditional Laboratories (NTL)
- Examples of remote laboratories for electrical and electronics engineering
- Examples of remote laboratories for digital electronics
- Evidence concerning the reliability of remote labs for digital electronics
- Conclusion

Twenty Five Years in Remote Experimentation

MEGA team: Make Experiments Great Again

Javier García-Zubía & Gustavo R. Alves

Papers

Aburdene et al. (1991). 'A proposal for a remotely shared control systems laboratory', in *Proc. of the ASEE 1991 Frontiers in Education Conference*

1991

Aktan et al. (1996). 'Distance Learning Applied to Control Engineering Laboratories', in *IEEE Transactions on Education*, 39(3), 320-326.

1996

S. Dormido-Bencomo (2002). 'Control Learning: Present and Future', in *IFAC Proceedings Volumes*, 35(1), 71-93. + 'Virtual and remote labs in education: A bibliometric analysis' (2016)

2002

Feisel, L. and A. Rosa (2005). 'The role of the laboratory in undergraduate engineering education', in *Journal of Engineering Education*, 94(1), 121–130.

2005

Ma, J. and Nickerson, J. V. (2006). 'Hands-on, simulated, and remote laboratories: A comparative literature review', in *ACM Computing Surveys*, 38(3), 1–24.

2006

Brinson, J. R. (2015). 'Learning outcome achievement in non-traditional (virtual and remote) versus traditional (hands-on) laboratories: A review of the empirical research', in *Computers & Education*, 87, 218–237.

2015

2016

2021

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Why 25 yrs. in Remote Experimentation?

> *"**Remote laboratories**, a method that can at least partially replace live experimentation, was **first developed by Aktan et al**. [216]. In a remote laboratory students use a computer to control an actual experiment that is in a different physical space. (...) Remote laboratories allow institutions to share expensive equipment, and equipment downtime is reduced."*

In: Froyd, J. E., Wankat, P. C., & Smith, K. A. (2012). Five major shifts in 100 years of engineering education. Proceedings of the IEEE, 100 (Special Centennial Issue), 1344–1360.

> *"**When it came time to publish our work**, we were fortunate to be able to submit it to a special issue on the applications of information technologies to engineering and science education of IEEE Transactions on Education, which drew attention to our results. One problem we encountered when we published our article was that **there were no existing keywords for papers to describe our work specifically enough** to bring it up in a search!. **We made up all of our keywords in our IEEE Transactions on Education paper**."*

In: Shor, M. H., et al. (2011). Second Best to Being There: An Historical Perspective. 'Using remote labs in education: two little ducks in remote experimentation', Javier García-Zubía, Gustavo R. Alves (eds.). ISBN 978-84-9830-335-3, pp. 27-52.

From a single remote experiment to a full remote lab environment …

- iLAB: 1998-2019. 2004 supported by Microsoft 25 M$. Jesús del Álamo & Judson Harward -> iLab Service Broker.
- RexLab 1998 and still running.
- WebLab-Deusto started on 2002, and still running –> LabsLand (spin-off).
- VISIR 1999 and still running in many countries.
- ISES & RemLabNet.
- LabShare 2008.
- GOLDi, eLAB, RCL, UNILabs, RemoteFarm, NCSLab, …

Projects

- DYNACORE (1998), D-SPACE (2001) Telescopes
- ReLAX (2000), PEARL (2000), CO-LAB (2001), eMERGE (2002)
- MARVEL, DERIVE, Lab@FUTURE, LiLa, …
- RexNET, OLAREX, ePRAGMATIC, ICo-op, NeReLa
- VISIR+, PILAR, EOLES, eLIVES
- GoLab, NextLab (Europe): https://www.golabz.eu, https://nextlab.golabz.eu
- Virtual Labs (India): https://www.vlab.co.in
- DECEL (Digital Electronics Collaborative Enhanced Learning) project: 2022 - …

New!

Remote Laboratories

UNED RemoteLab Costa Rica

- LabRem
- ilough-Lab
- WebLab-Deusto
- Circuit Warz
- PhysicsLabFarm ISEP
- Lab-on-Web
- UNILabs
- eLab3D
- RexLab
- RemLabNet
- Remote farm
- Remote Controlled Labs RCL
- VirtualRemoteLab LMU
- GOLDi
- Online Experimenta FEUP
- e-lab
- OpenScienceLabs OU
- iLAB Standford
- iLAB MIT
- Coldfire Lab (LabShare)
- NCSLab
- FarLabs
- NANSLO
- NetLab

Books

- *Impact of Advances in Computing and Communications Technologies on Chemical Science and Technology* (NRC, 1999)
- Lab on the Web: Fjeldly and Shur (2003) Willey and Sons
- Book series from Deusto Publications: Luis Gomes, Gustavo Alves, Olga Dziabenko & Javier García-Zubía 2006, 2011, 2013
- Springer: Michael Auer, Abul Azad, Ton de Jong, Judson Harward
- Teresa Restivo & Alberto Cardoso, Miroslava Ozvoldová & Franz Schauer
- *Emerging Technologies in Engineering Education: Do we need them and can we make them work? NMC 2017*
- *Development of a Remote Laboratory for Engineering Education.* Wang *in 2020*
- **Remote Laboratories: Empowering STEM Education with Technology. WSP in 2021. Take the discount**
- … and more to come!

Future … ?
… a glimpse from present times …

"remote laboratory
Search term

"remote laboratories
Search term

"remote lab
Search term

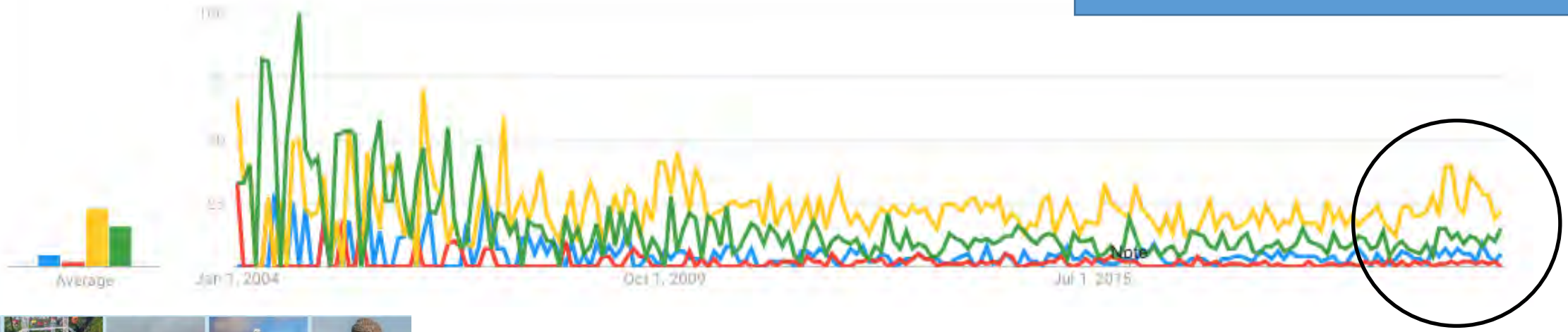
"remote labs
Search term

Google Trends

Worldwide | 2004 - present | All categories | Web Search

Interest over time

Numbers represent search interest relative to the highest point on the chart for the given region and time. A value of 100 is the peak popularity for the term. A value of 50 means that the term is half as popular. A score of 0 means there was not enough data for this term.



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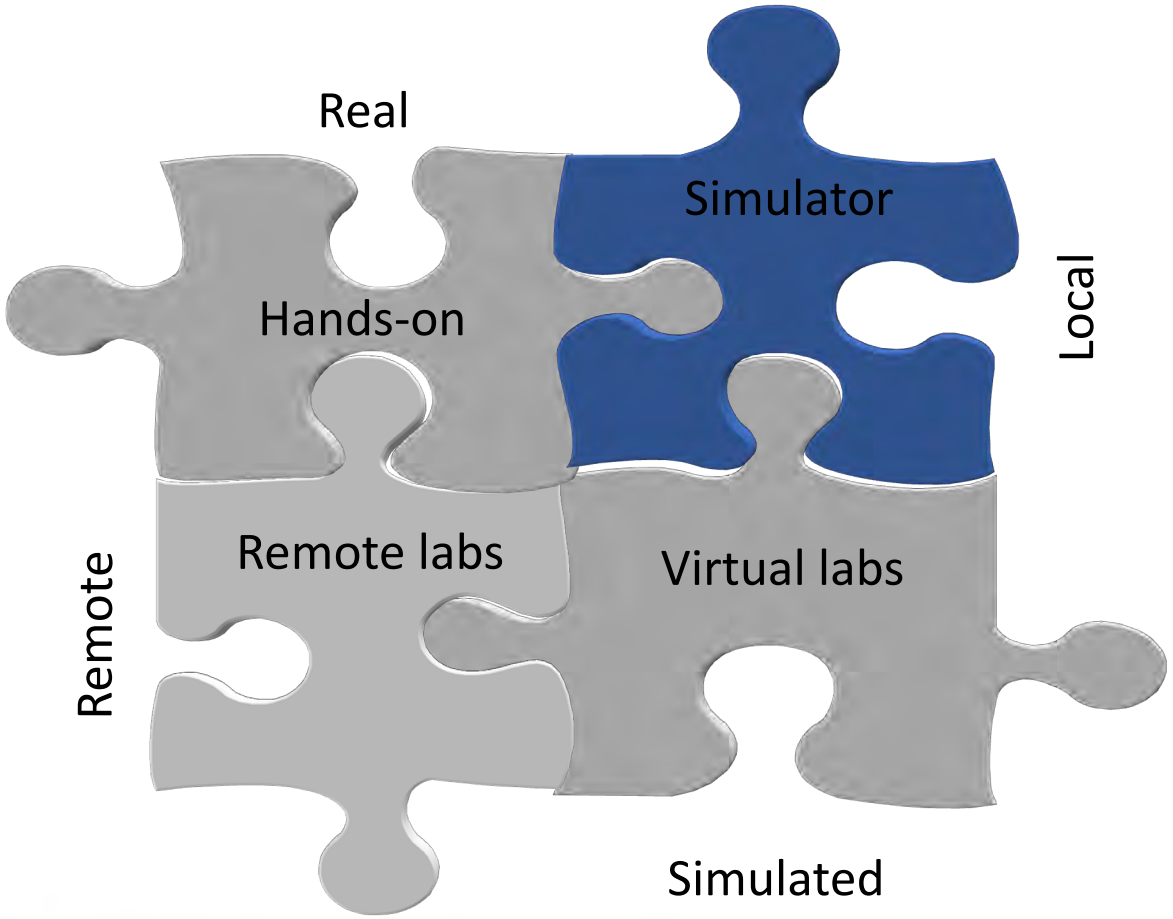
Digital experiences in technical higher education

Using remote and virtual labs in technical higher education

Hands-on, remote and virtual labs



- Criteria
  - Type of access
    - Local
    - Remote
  - Nature
    - Real
    - Simulated
- Experimental skills vs. lab type
  - Soysal (2000) - EE
  - Ma & Nickerson (2006)

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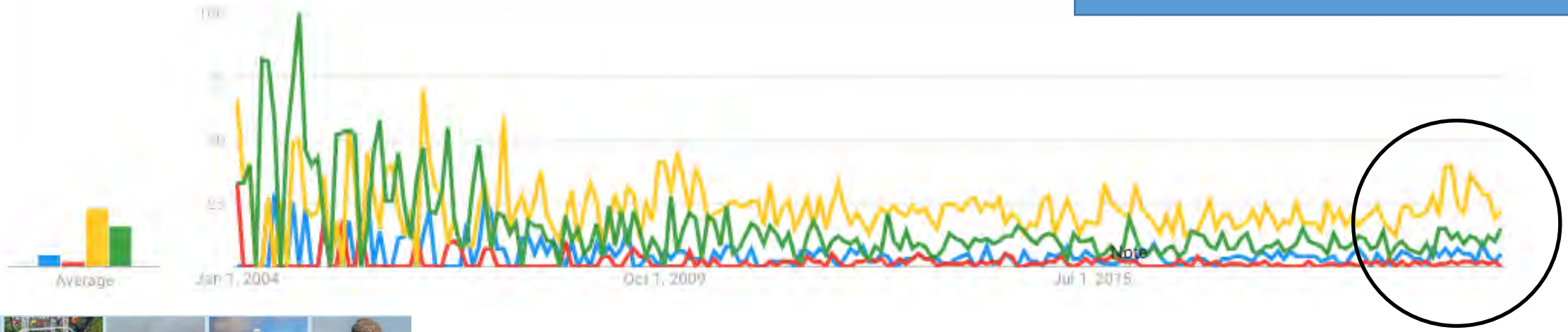

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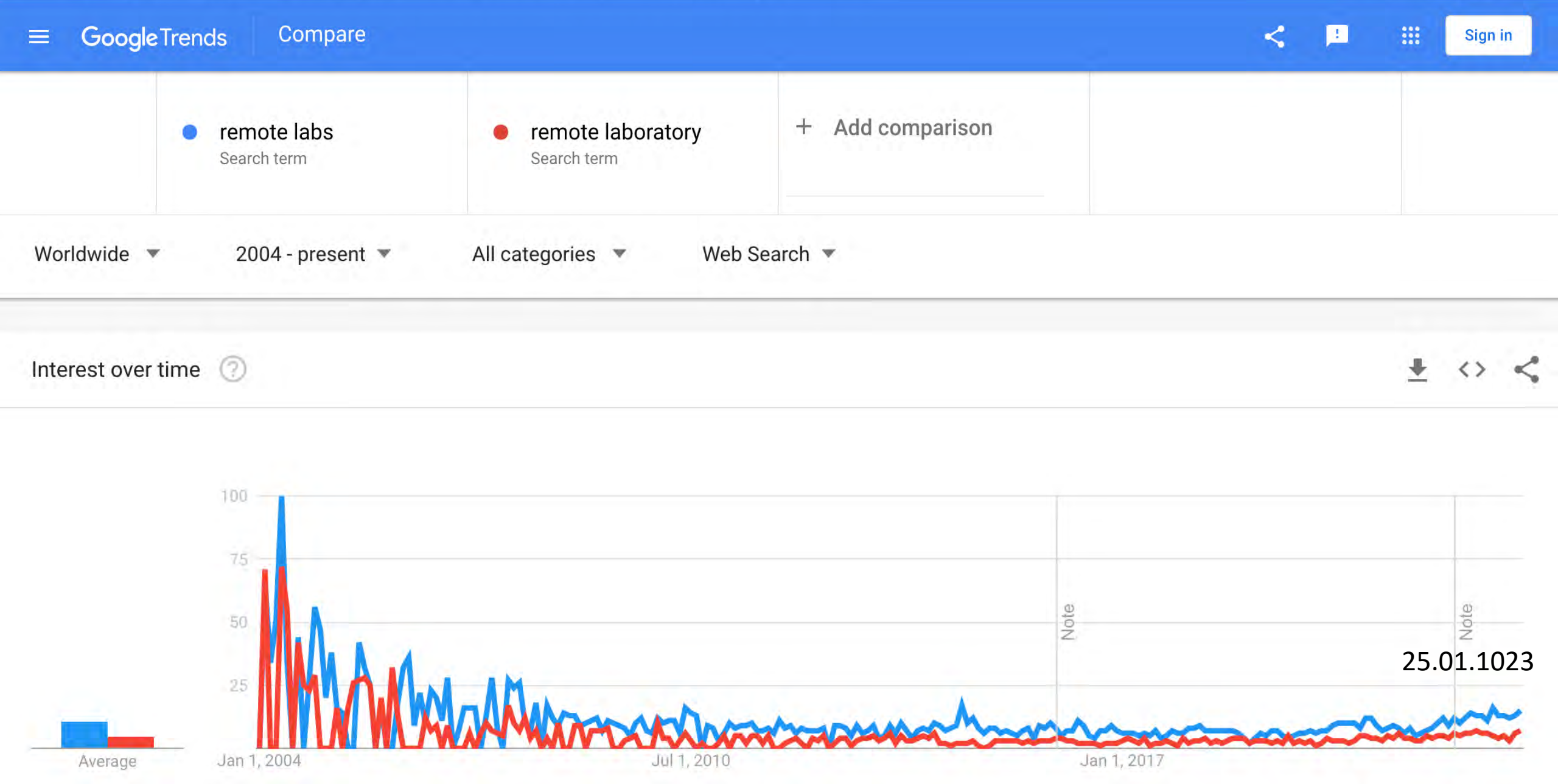
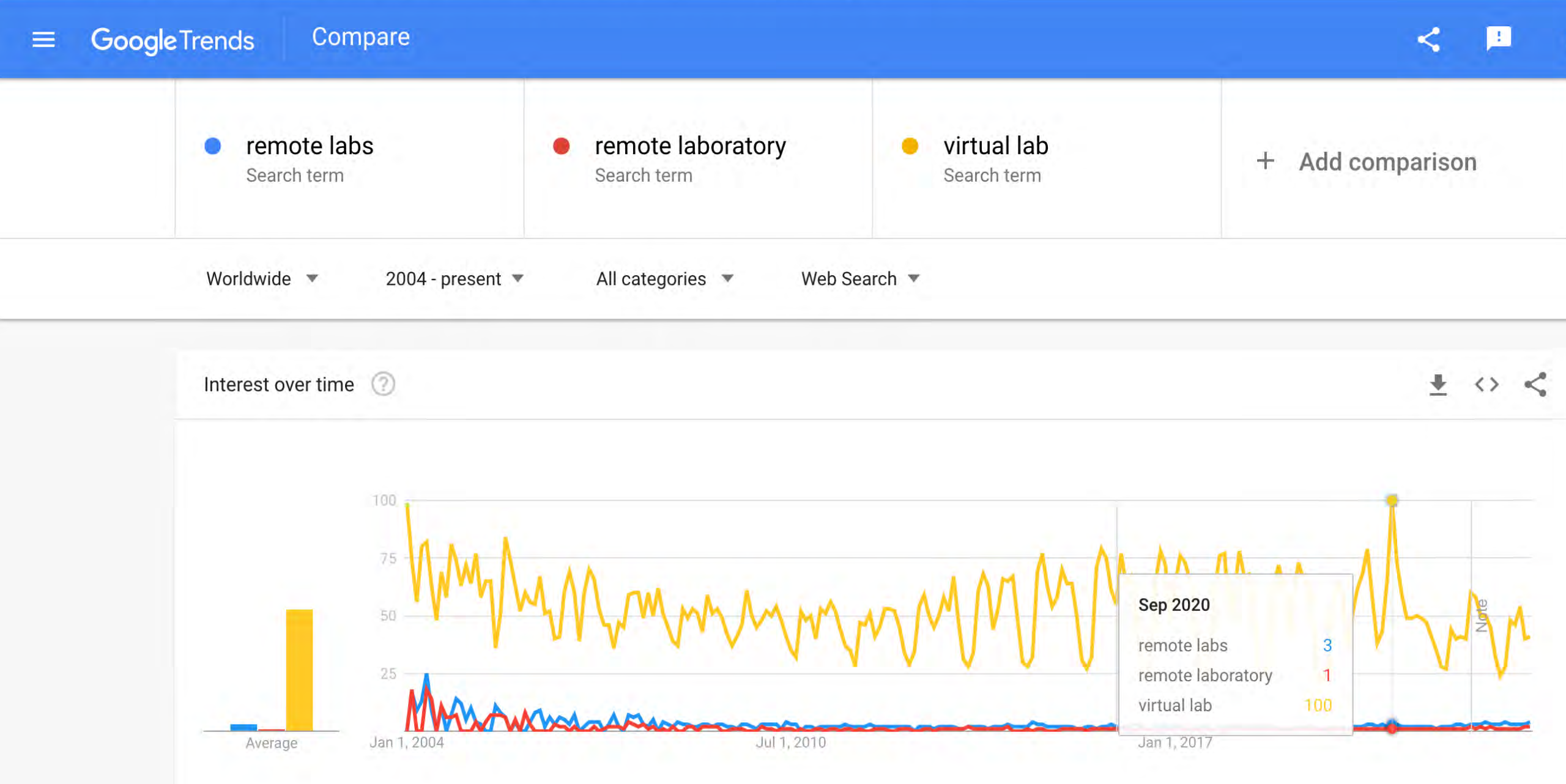

Google Trends
Compare
Sign in
remote labs
Search term
remote laboratory
Search term
Add comparison
Worldwide
2004 - present
All categories
Web Search
Interest over time
100
75
50
25
Note
Note
Average
Jan 1, 2004
Jul 1, 2010
Jan 1, 2017
25.01.1023


Google Trends
Compare
remote labs
Search term
remote laboratory
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virtual lab
Search term
Add comparison
Worldwide
2004 - present
All categories
Web Search
Interest over time
100
75
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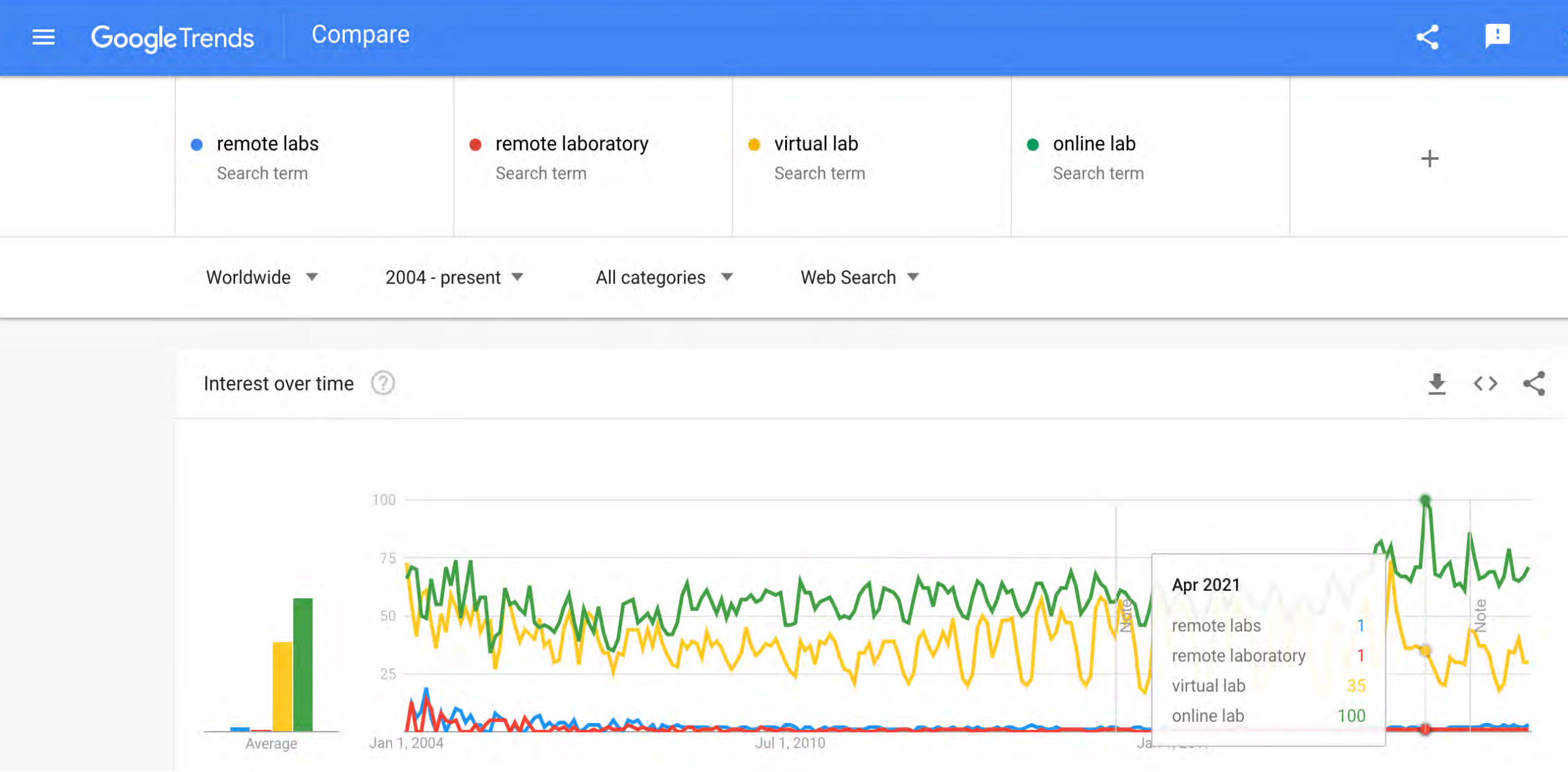
Average
Jan 1, 2004
Jul 1, 2010
Jan 1, 2017
Note
Sep 2020
remote labs 3
remote laboratory 1
virtual lab 100


Google Trends
Compare
remote labs
Search term
remote laboratory
Search term
virtual lab
Search term
online lab
Search term
Worldwide
2004 - present
All categories
Web Search
Interest over time
100
75
50
25
Average
Jan 1, 2004
Jul 1, 2010
Note
Note
Apr 2021
remote labs 1
remote laboratory 1
virtual lab 35
online lab 100