

# Final Report for the CIG Tectonics Modeling Workshop 2020

<b>About</b>	<b>1</b>
<b>Program</b>	<b>2</b>
Session 1: Introduction to ASPECT basics.	2
Session 2: Modifying and Coding in ASPECT	3
Session 3: Lithospheric Deformation	3
Session 4: Two-Phase Flow	3
Session 5: Complex Model Design with the Geodynamic World Builder	4
Optional discussion session	4
<b>Statistics about participants</b>	<b>5</b>
<b>Survey results</b>	<b>8</b>
<b>Lessons learned</b>	<b>9</b>
<b>Conclusions</b>	<b>10</b>
<b>Appendix - Survey Results</b>	<b>11</b>

## About

The 2020 Tectonics Modeling Workshop was a virtual workshop held July 20-24, 2020. The goal was to provide an opportunity for both new and experienced modelers to receive hands-on training on the fundamentals of long-term tectonic modeling using the ASPECT code. The workshop was originally planned to be an on-site workshop in Golden, Colorado preceding the 2020 Tectonics Community Science Workshop. Due to the COVID-19 pandemic, it was changed to a virtual workshop through Zoom and held the week preceding the 2020 Tectonics Community Science Workshop.

The organisation of the workshop was led by Rene Gassmoeller (UC Davis) and John Naliboff (UC Davis) along with Wolfgang Bangerth (Colorado State University), Juliane Dannberg (University of Florida), Menno Fraters (UC Davis), Anne Glerum (GFZ Potsdam), Timo Heister (Clemson University) and Lorraine Hwang (UC Davis). Registration was first-come, first-served.

Out of the over 100 participants pre-registered, 74 researchers (predominantly graduate students) attended. Announcements were sent to CIG, geo-tectonics, Geoprisms, and Myres email lists.

The tutorial used the geodynamics software ASPECT as the main tool to teach the participants about tectonic modelling.

## Program

The workshop consisted of 5 broad topics spread over 5 days. Daily sessions were adjusted to accommodate topics from the previous day as needed. Formal sessions beginning at 07:00 PDT lasted 3 hours per day followed by 1 hour of discussion and individual help for participants, with breaks as appropriate. The compressed format was necessary to allow participation from different time zones, but also to accommodate typical attention spans for online workshops. The full agenda can be found on the CIG website (<https://geodynamics.org/cig/events/calendar/2020-tectonics-modeling-tutorial/>).

The original program had planned for presentations by participants on the models they intended to build during the tutorial or the research they were conducting. However, due to the large number of participants and the limited time available per day, this component was cancelled.

All presentations and files used during the workshop were made available to the participants along with a fully functioning ASPECT installation provided as a VirtualBox image. Recordings of individual sessions were also made available on the CIG youtube channel immediately after their completion. This practice enabled workshop participants to review material prior to the subsequent sessions, and also enables any member of the community to complete the workshop independently.

### Session 1: Introduction to ASPECT basics.

Day 1, Session 1 began with a welcome talk and introduction of the workshop organizers. The tutorials session, led by Wolfgang Bangerth and Timo Heister, provided background information on ASPECT, its general philosophy and how models are described in practice, and showed users how to use it in the provided VirtualBox image. By the end of the session participants were able to edit an ASPECT parameter file, run that parameter file with ASPECT, and visualize the results both with Paraview and plot statistics using gnuplot.

Participants were then asked to run the Rayleigh-Taylor instability 2D convection cookbook, varying the refinement level and viscosity (which controls the Rayleigh number). Run results were compiled into an online spreadsheet, graphed, and discussed, and matched the expected relationship between Rayleigh number (viscosity) and Nusselt number (heat flux).

## Session 2: Modifying and Coding in ASPECT

Session 2 on day 2 was led by Rene Gassmoeller. The goal of this session was to help participants to compile the ASPECT code in release mode (as opposed to debug mode) and enable them to make simple modifications to the code. The concept behind the code structure was explained and participants were guided on how to make a new plugin from existing ones. This also allowed participants to run all ASPECT cookbooks and benchmarks since some of them require the compilation of separate plugins. Rene Gassmoeller also explained the different types of free surface implementations and how to use them.

## Session 3: Lithospheric Deformation

Session 3 was led by John Naliboff and Anne Glerum. The session started at the end of the second day and lasted till the beginning of the fourth day. It covered the relevant physics and rheology for lithospheric deformation, lessons on designing models from hypothesis to set-up, and in-depth examples of four different relevant crustal or lithospheric scale cases: A visco-elastic bending beam, extension of continental lithosphere, brittle thrust wedge formation, and intra-oceanic subduction. During the discussion of the model set-up and input file for these examples, time was taken to also explain relevant topics like rheology, linear and nonlinear solver schemes and their controlling parameters, mesh-dependency of plasticity, different advection methods (Volume of Fluid, particles, and compositional fields), possible issues particular to modelling subduction interfaces, and the combined use of static and dynamic strategies for mesh adaptation. Online inspection of the model results also covered ParaView (visualization software) filters and comparison to results of other codes and analog experiments.

## Session 4: Two-Phase Flow

Day 4, Session 4 was led by Juliane Dannberg and started with an explanation of how to cite both ASPECT and different parts of the code. Most of the session focussed on explaining how two-phase flow is implemented in ASPECT and how to use it in practice. This session was set up around the example of a mid-ocean ridge. First, the relevant equations and parameters for using the melt solver were explained and participants were pointed to where they could find more information in the online parameter documentation. In the process, hands-on experience – like what mesh size is needed to get realistic results, or how to use features like restarting models effectively – was shared. Advanced melt concepts and processes, like permeability and melting and freezing, and the formulation of the systems of equations, were also shown to the participants. At the end of the session, participants had become familiar with all the components of a model that includes melt.

## Session 5: Complex Model Design with the Geodynamic World Builder

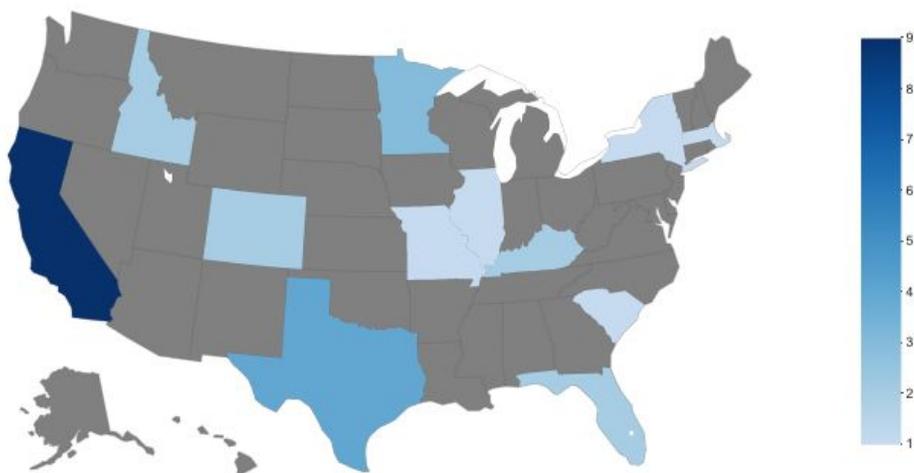
Day 5, Session 5 was led by Menno Fraters. The session started with an explanation of the types of models that can be built, and what the most appropriate approach of model building is for different situations. It then continued with the case for which the Geodynamic World Builder (GWB) is the most appropriate: complex synthetic model design. After a high level introduction to the concepts behind the GWB, which is part of the ASPECT release, the participants were shown the reference model they were going to build from scratch. That reference model was built in ten steps, which the participants could also do themselves using the files provided in the ASPECT virtual machine. Several exercises were included for the participants to do during the breaks. After reaching the reference model, some more advanced features of the GWB were explained and participants were pointed to resources where they could find more information, ask questions, and request new features.

### Optional discussion session

After every day, there was an optional discussion session, which was attended by about 20-25 participants (including some of the organizers) each day. These discussions were led by Rene Gassmoeller. During this session, participants were encouraged to turn on their microphones and cameras to enhance participation. These sessions consisted mostly of three different types of discussions: (1) specific questions about previous tutorial session, (2) general discussion questions, and (3) individual questions mostly pertaining to setting up models with ASPECT. For the latter type, participants were usually assigned an organizer with relevant experience to discuss their questions in a separate Zoom breakout room. Questions in categories (1) and (2) were discussed in the main Zoom room with all participants. These discussions typically lasted until the end of the allotted time (1 hour).

## Statistics about participants

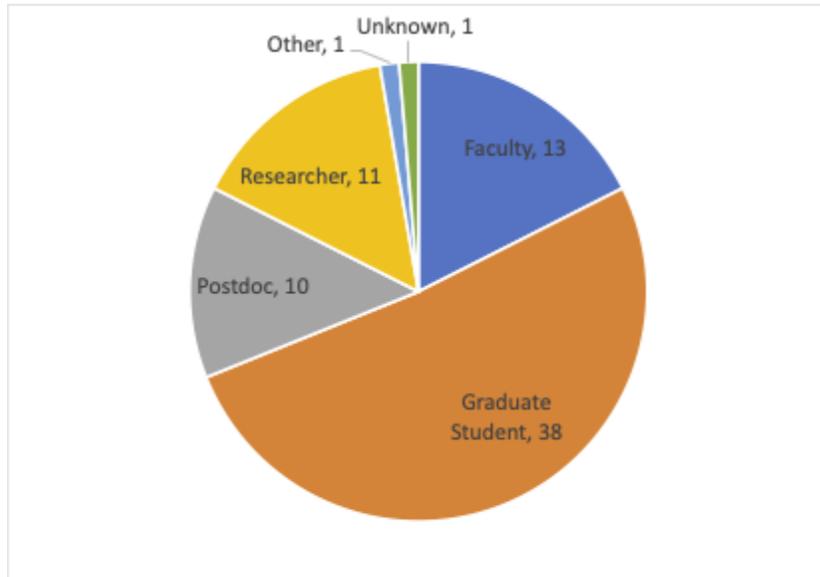
Over the 5 day event, at least 74 unique participants were registered via zoom (however, Wednesday's usage records were not available). Participants were predominantly graduate students with the majority of participants located internationally and spanning time zones from Australia Time to Pacific Time. A large number of participants were from South America who found out about the meeting from the geo-tectonics email listserv.



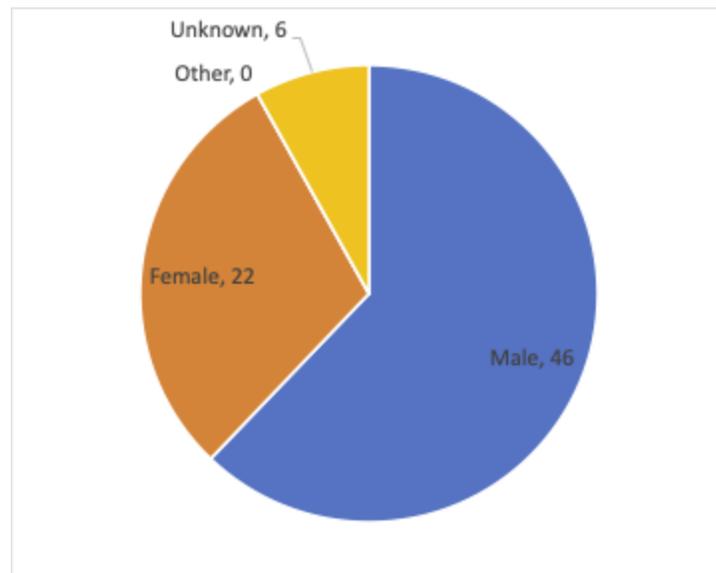
Total United States Participants: 29



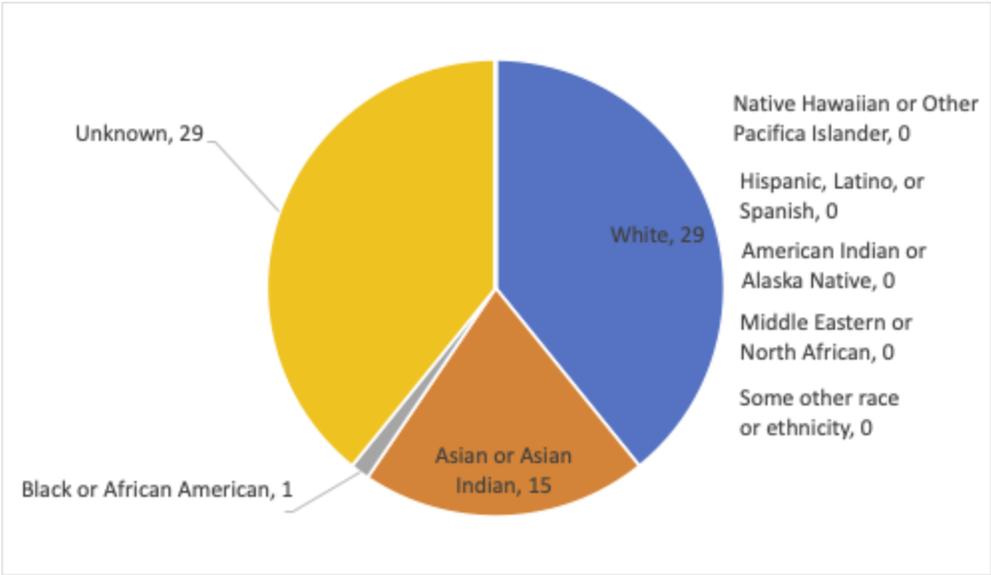
Total Worldwide Participants (except U.S.): 44



Career Stage. 53% of responders were Graduate Students.



Gender Identity. 32% of responders self-identified as female.



Ethnicity. A large portion of respondents (39) chose not to report their ethnicity.

# Survey results

All tutorial participants were sent a survey and given one week to respond, see Appendix. Free text responses are not recorded here but have been made available to all the organizers.

In general, the tutorial met or exceeded participants' expectations for content and level of material. Participants overwhelmingly liked the virtual tutorial format with several expressing they would not have been able to attend otherwise due to expense of travel and/or visa restrictions. The presenters received positive feedback.

Participants expressed a desire for more example problems to work on and gave suggestions for additional topics and materials for future tutorials. The overall pace of the material was good but the virtual format did not allow for instructors to gauge the uptake of the room and adjust nor gave the participants the afternoon to work through problems and interact with others on their research as would have happened during an in person tutorial. ASPECT experts were on chat answering questions throughout the tutorial which was extremely helpful but also divided attention away from the presentation. We note that this happens in an in-person meeting as well as helpers circulate through the room.

# Lessons learned

1. Technical skills: Participants have a wide range of backgrounds and proficiencies in running in terminal windows, theoretical geodynamics, and modeling building. More theoretical background up front and resources for technical reference (linux, C++, etc.) would be useful for participants.
2. Pre-workshop prep: A pre-workshop virtual help session to help those having difficulty installing VirtualBox. While most had no trouble, participants had a variety of problems usually involving their system (e.g. insufficient memory per core, operating system, etc.).
3. Participant persistence: High quality instructions and targeted material contributed to high retention rate. The tutorial started with 73 participants with 57 by Day 4. Day 5 again had a maximum of 66 participants, showing that participants were motivated enough to come back day after day.
4. Multiple screen presentation: Showing the full screen and not just the presentation was easier for the participants to follow.
5. Breaks: We found it important to keep to breaks of at least 15 minutes.
6. Format: The virtual tutorial was overwhelmingly well liked by participants, but made it difficult to read the room and help individual participants that did not “speak up” through chat or other means.
7. Expert help: Having experts answering questions on chat allowed the presenter to concentrate on the presentation and interact as necessary. However, on specialized topics, such as the World Building tutorial, this was sometimes not possible due to lack of in-depth knowledge beyond the presenter.
8. Connectivity: Slow connections cause slides to lag behind the speaker; showing animations and videos is generally difficult. As a consequence, we learned that slower transitions and more pauses between interactively-demonstrated actions help everyone stay caught-up.
9. Homework: We should have more examples or homework problems to reinforce learning.

# Conclusions

This workshop was the first virtual workshop for ASPECT and targeted beginning users. Recordings of this workshop were not only useful for participants who missed sessions but for future tutorials as we think about teaching more advanced and/or specialized topics. Survey respondents indicated a wide range of future tutorial topics of interest to tackle a similarly wide range of research interests.

Generally, not having to travel aided attendance for many, although this of course trades off with the loss of establishing personal/research connections and the unavailability of long focus time to work on cookbook problems as well as research model building with experts in the room. In-person meetings also help to sustain community building by providing both community leaders and users an opportunity to interact. Finally, the need to cater to participants spread out over all major time zones very much limited the amount of time we can use every day. Nevertheless, it is clear that an in-person tutorial would not have attracted nearly as many participants.

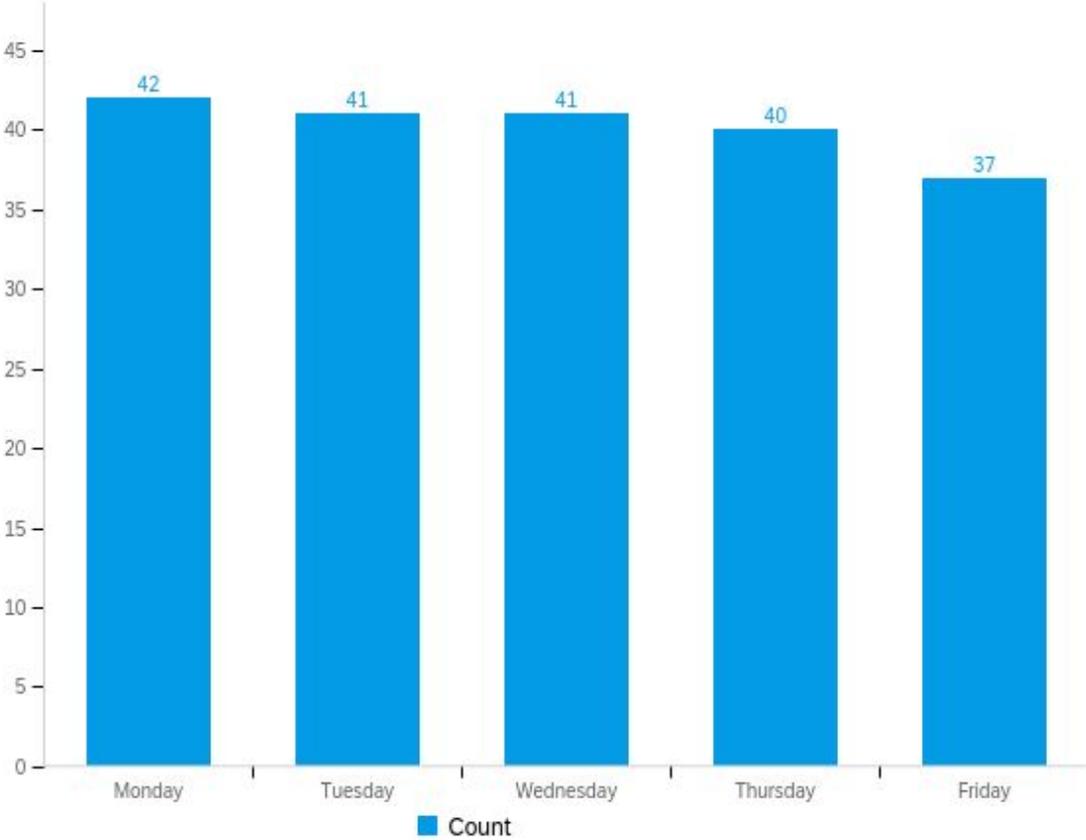
Exploring hybrid in-person/virtual workshop models would balance the different needs. This might include making the in-person conversation between experienced instructors and workshop participants online as well, or co-locating some participants with some of the instructors. However, as a cautionary note, a careful assessment of technological capacity in delivering a hybrid tutorial must be assessed for the adequacy of whole room audio, projection of multiple screens, and bandwidth.

Specifically on the topic of this workshop, the focus on lithospheric tectonics attracted large interest especially from the international community. International participants were dedicated – joining the meeting at very early morning hours in their time zone, and tended to persist joining for the entire meeting. Clearly, there is an international demand in which virtual tutorials can help meet; there is also a substantial interest in tectonic modeling that is apparently not currently met by existing software, and driving adoption of (or at least thinking about) ASPECT in an area in which it has only recently been used.

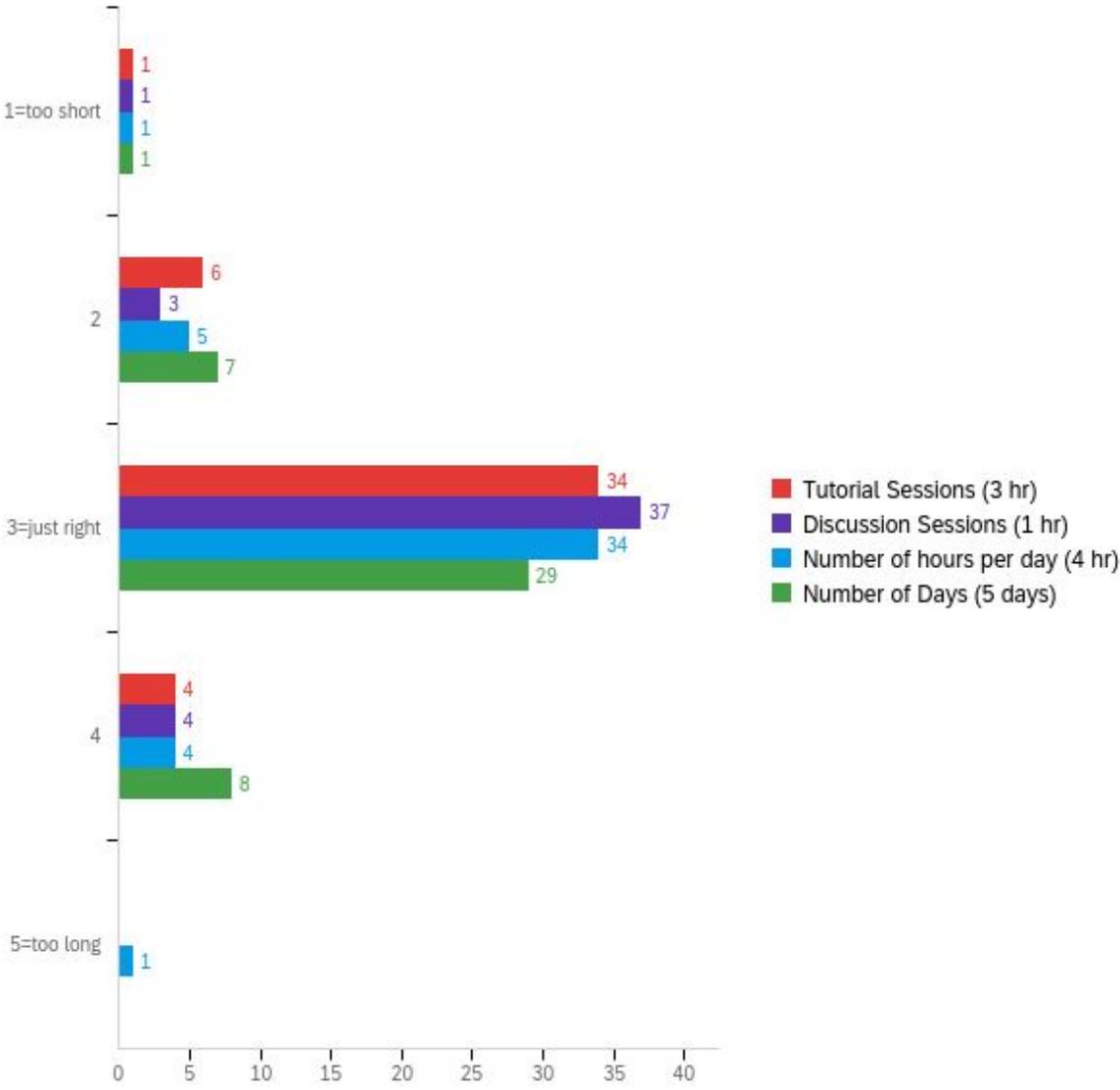
# Appendix - Survey Results

Total Number of Respondents: 46 (62%) responded and completed the survey.

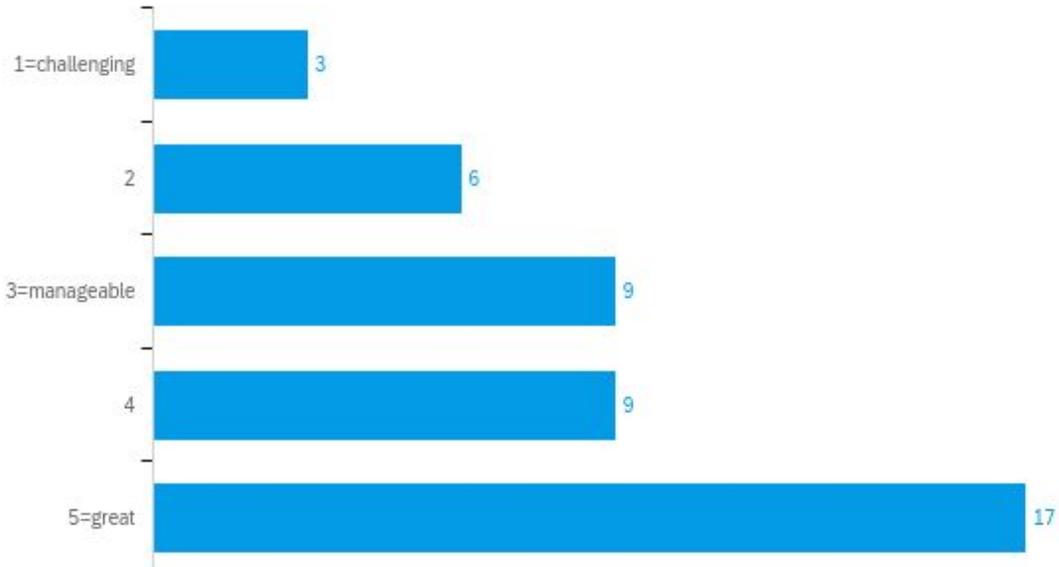
## Attendance



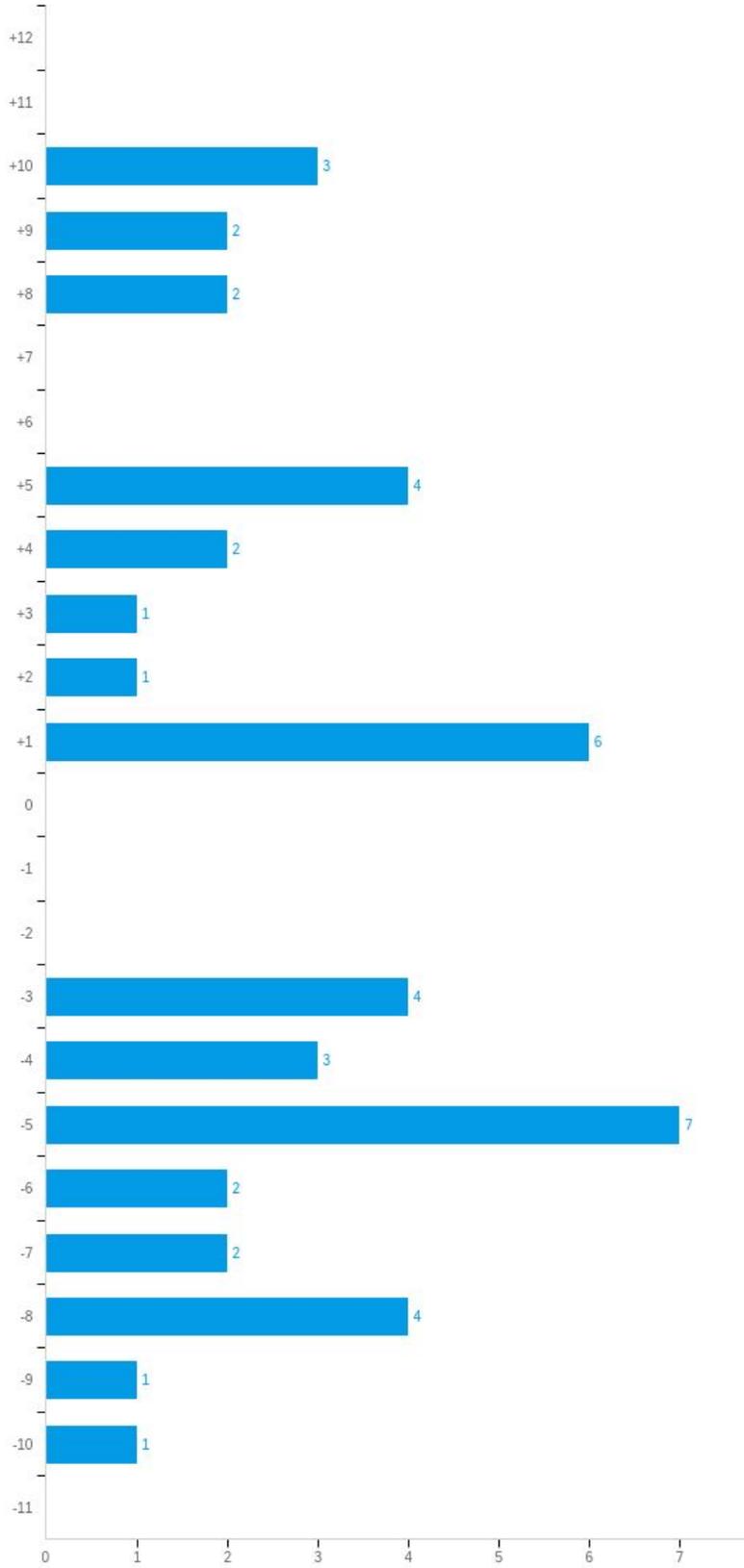
# Duration



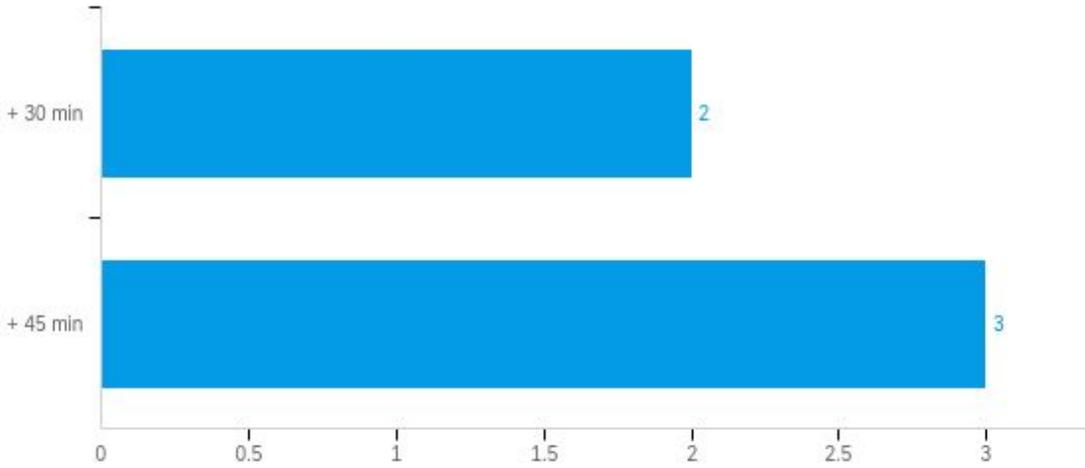
Time of Day



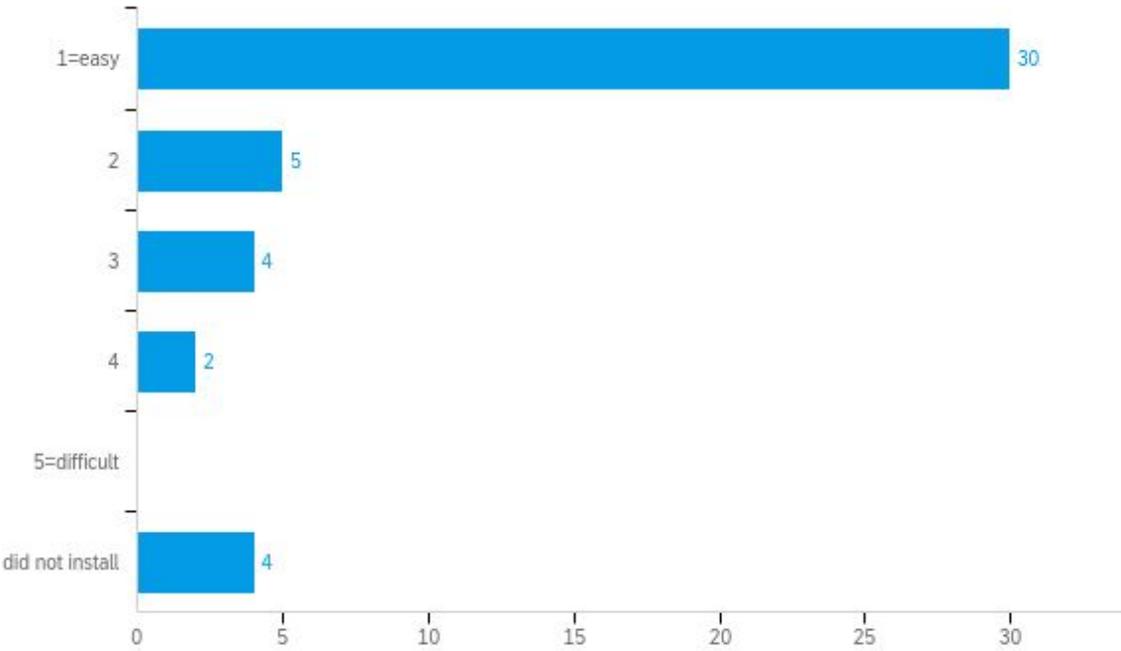
Time Zone (UTC)



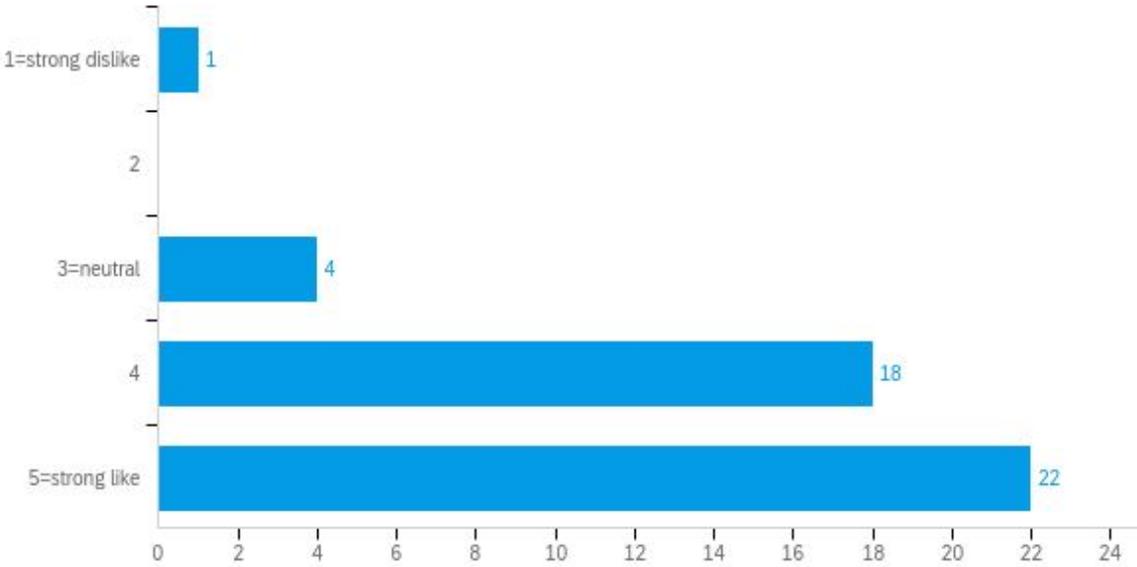
Add to GMT:



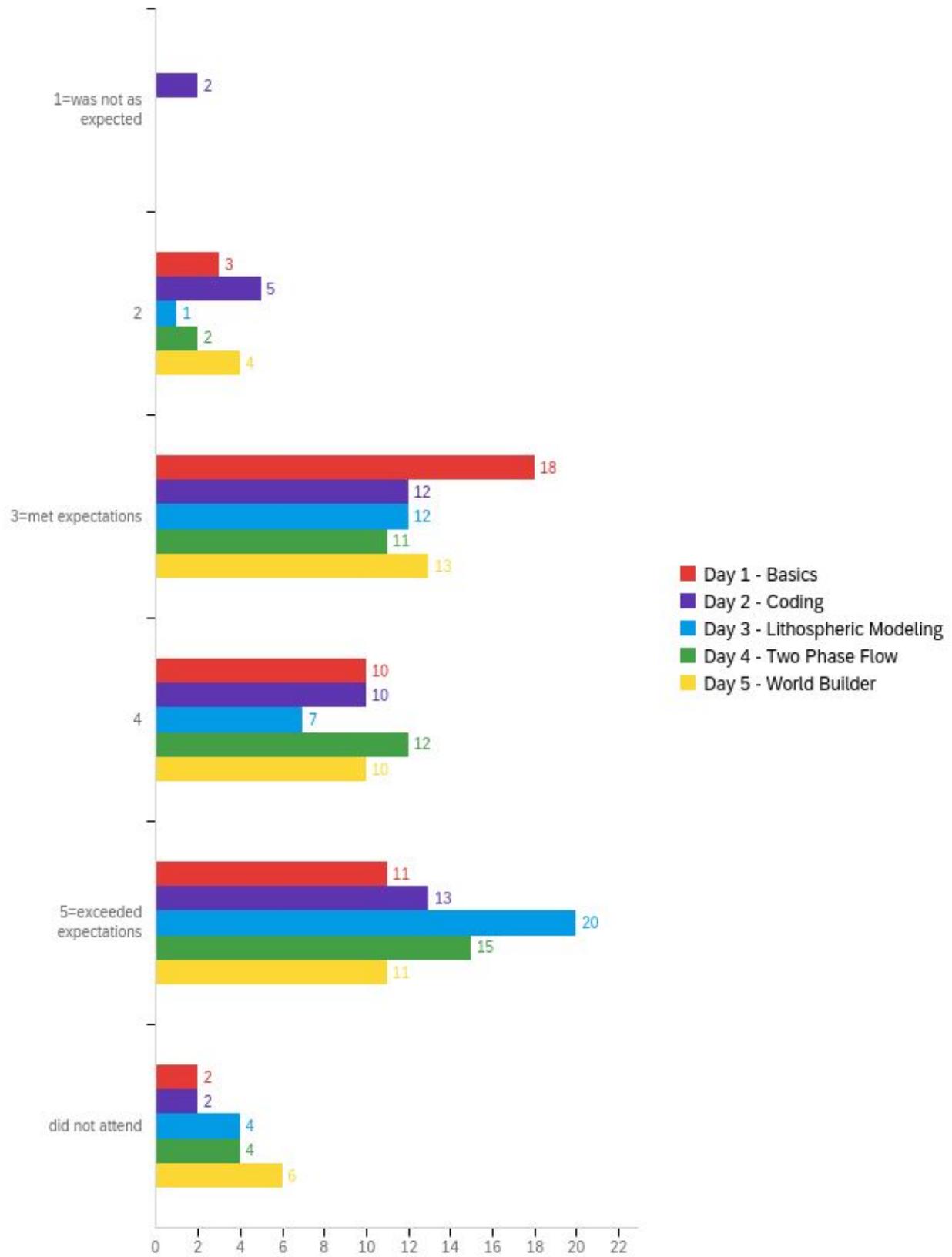
Virtual Box Installation



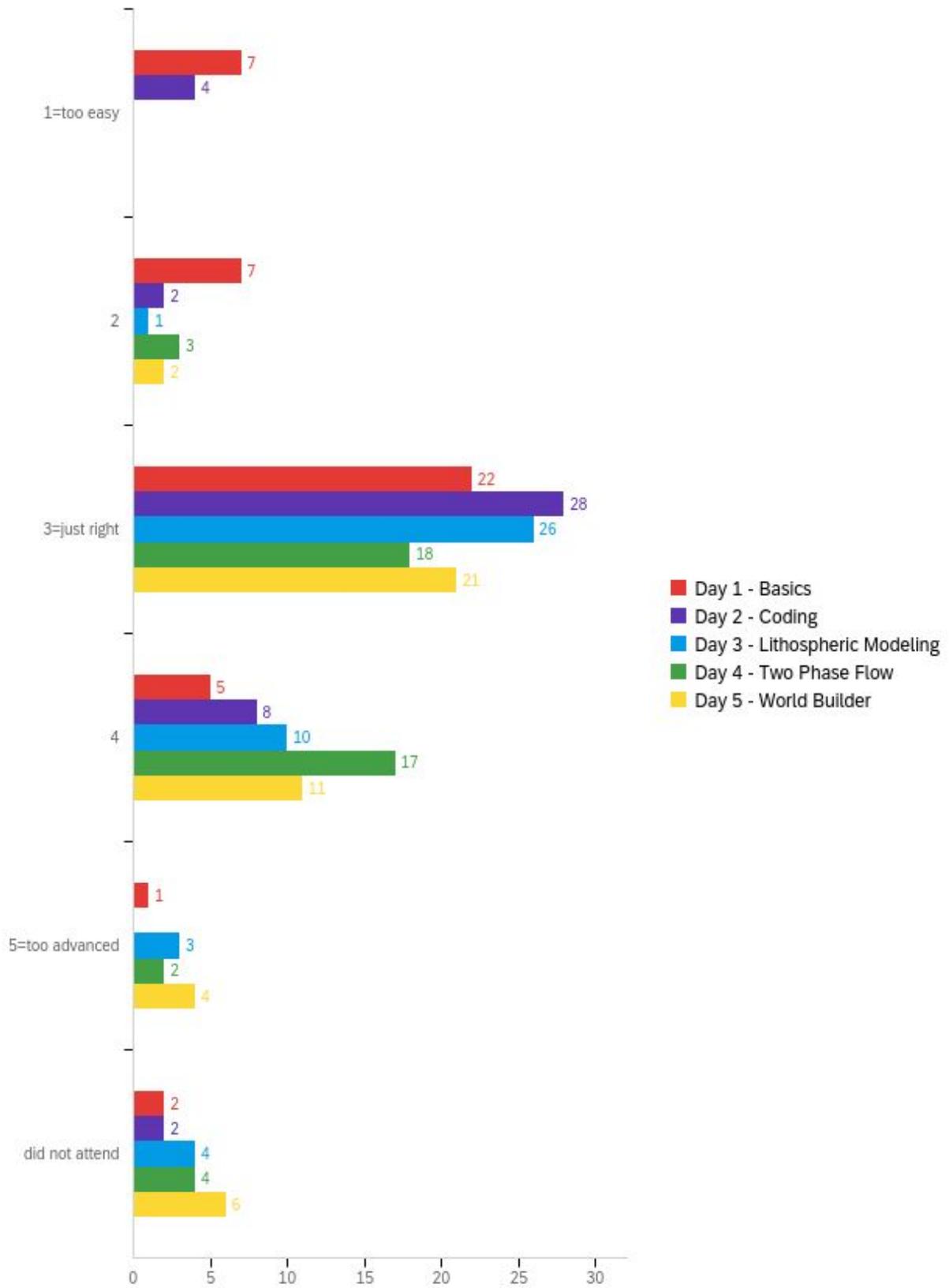
# Virtual Tutorial Format



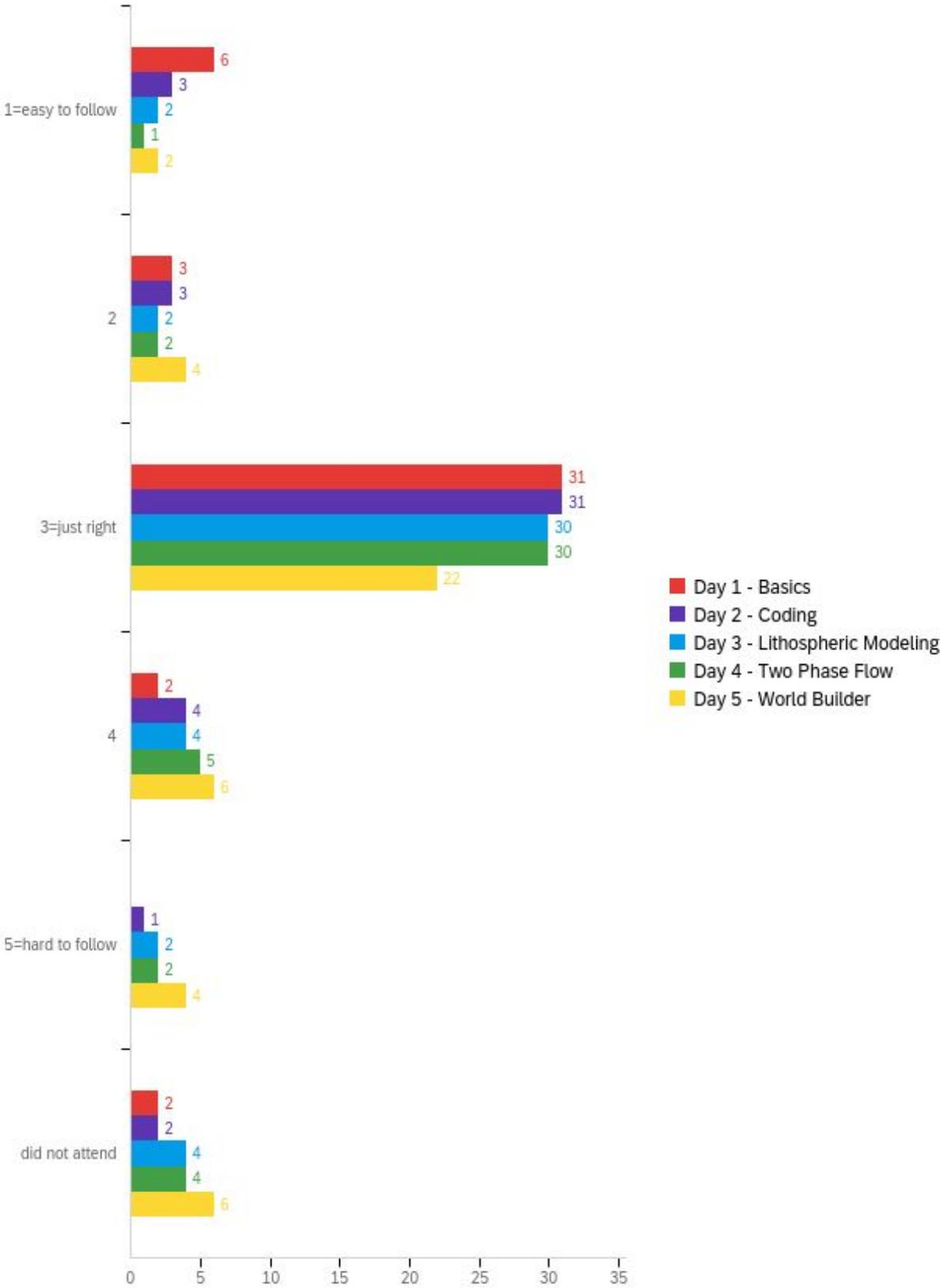
## Tutorial Content



## Level Content



# Level of Example Problems



# Presentation Speed

