Final Report

Using A Stream Geomodel to Enhance STEM Courses and An Active Learning Space

PI Ross Guida

Using A Stream Geomodel to Enhance STEM Courses and An Active Learning Space

PI:
Ross Guida, Ph.D., Associate Professor of Geography, Department of Environmental and Geosciences; ross.guida@shsu.edu

Co-PIs:
David Moss, Ph.D., Assistant Professor of Geology; dxm112@shsu.edu

Renjie Zhou, Ph.D., Assistant Professor of Geology; rxz013@shsu.edu

Joseph Hill, Ph.D., Associate Professor of Geology; jch031@shsu.edu

Amber Ulseth, Ph.D., Assistant Professor of Biological Sciences; aju005@shsu.edu

Current and Pending:
We are concurrently applying to the PACE Center for $8,000 to cover the total equipment costs quoted and stipends for setup and related course material preparation.

Budget:
$8,000 toward an EM2 stream table and accessories package.

Spring 2023 STEM Courses with projected enrollment:

GEOG 1401 Weather and Climate (485 students)*
GEOG 4432 Geomorphology (25 students)
GEOL 1403 Physical Geology (110 students)*
GEOL 1404 Historical Geology (120 students)*
GEOL 1405 Geologic & Environmental Hazards (140 students)*
GEOL 3326 Environmental Geology (30 students)
GEOL 3330 Oceanography (30 students)
BIOL 1401 Environmental Science (75 students)*
BIOL 3409 General Ecology (136 students)

* core Life and Physical Science course

Potential Impact: 1,150 students across 9 courses, including up to 930 in intro core courses, for Spring 2023. Fall enrollments are typically higher for impacted courses.

Project Narrative

Executive Summary:
Hands-on, applied activities improve student engagement and can impact course outcomes through active, peer-to-peer learning. Through this STEM Center Teaching Enhancement Grant, five COSET faculty will integrate a stream table/geomodel into up to nine courses during the Spring 2023 semester with projected enrollments that total 1,150 students (up to 930 in intro core science courses). Though all of the courses impacted by this proposal discuss rivers at varying levels of depth, we currently have no 3-Dimensional models that allow students to observe a diversity of processes during the one to three-hour time periods allotted for lecture and/or lab. Observations of a similar nature in the field can take months or years and do not allow students to actively manipulate parameters themselves like they can with an EM2 geomodel. Currently, students observe photos or watch time-lapse videos that are less impactful. By integrating a stream geomodel, and rewriting some labs and lectures, we hope that actively learning how rivers are impacted by human beings and how streams evolve over time will become more meaningful for students and help with material retention. All of our proposed budget for this project will be applied toward the purchase of the geomodel. We are seeking additional funding to purchase the bulk of the necessary accessories from the PACE Center through a TIG Grant. Finally, this stream model is portable but will be used in primarily in an Engaging Space, LDB 339, that will be ready for use Spring 2023.

Rationale
Engineering and geoscience students learn more effectively and have more confidence when learning through applied concepts, case studies, and active learning (Holley 2017). Students also perform better when active learning is implemented in geoscience courses, especially when they are able to connect material to real-world applications that impact them (Russell et al., 2016). Further, in upper-level geoscience courses, student motivation increases when they perceive that they are learning skills that are directly applicable to their careers (Huguet et al., 2020).

To increase active learning participation and the use of applied concepts, we propose integrating a stream table (see Fig. 1) into multiple lectures and labs across Environmental and Geosciences and Biological Sciences. Though modern physical science research is often dominated by computers, effective learning occurs when students use stream tables to observe fluvial processes (Wikle and Lightfoot, 1997). This is especially important given students often have trouble observing key processes through diagrams, photographs, etc. (Wikle and Lightfoot, 1997). Though the natural environment is valuable for field experiences, students can't control all variables in the field. However, using a stream table/model allows groups of students to work together to control variables and parameters relatively easily that impact sediment, flooding, and flow velocity; these experiments result in "compressed-time" mental maps that improve understanding (Wikle and Lightfoot, 1997). Moreover, student evaluations from other campuses demonstrate that students learn fluvial concepts better through the use of applied and active stream exercises using 3-D models to show sea level-change impacts as well as landform changes (Lillquist and Kinner, 2002). Stream tables also allow for student observations of watershed-river channel interactions (Lillquist and Kenner, 2002), concepts that can be hard to observe at scale in the real world during field trips.

Materials and Methods
At present, we have no existing stream geomodels at SHSU, though concepts and processes that relate to streams and flooding are covered in numerous courses in COSET, including: Weather and Climate; Geomorphology; Physical Geology; Historical Geology; Geologic and Environmental Hazards; Environmental Geology; Oceanography; Environmental Science; Ecology; Stream Ecology, Hydrology; Hydrogeology; and Sedimentology and Stratigraphy. Given page limits, we have listed courses that are offered Spring 2023 with expected enrollments on the cover page. While students can observe some fluvial processes and landforms at SHSU's Field Station or in local streams, other processes take weeks,

months, or even years or decades to observe in natural systems. By using an EM2 stream table/geomodel with related accessories, students can manipulate flow and other variables to observe active river and sediment-related processes (e.g., flood impacts, dredging, channel evolution, delta formation and degradation, erosion, etc.) on a much shorter temporal scale conducive to lecture and lab time limitations. Additionally, student groups will be able to make changes to the system to observe how human beings and the physical river environment are interconnected. These key human-environment interactions are highly motivating for students based on initial data from PI Guida and co-PI Moss' NSF Geopath's grant (Guida et al., 2022; Moss et al., 2022). All of our proposed budget (see below) will be applied to the river geomodel equipment.

Expected Results and Dissemination Plan

As we integrate the stream table/geomodel into the aforementioned courses, we will ask Spring 2023 classes for anonymous feedback on how its use impacted learning during the related units. We will present these results at SHSU's Fall 2023 Teaching and Learning Conference. If the STEM Center hosts another symposium this Spring, we also look forward to sharing any initial results that may be available at that time. In addition, we intend to share lab materials with other intro instructors at SHSU that would like to integrate stream or river labs into their curriculum.

Dissemination of the physical model is also possible. While we plan to keep the table in LDB 339, which is currently being renovated as a PACE Engaging Space/Active Learning classroom, the room can be scheduled by other departments as part of the Engaging Spaces agreement. However, the table is also portable and can be used by SHSU faculty for other recruiting or grant-related events when it's not reserved for lectures or labs.

Budget and Justification:

We are requesting $8,000 toward a $13,799 total for an EM2 stream table/geomodel (Fig. 1). As per the full itemized quote provided, the total is as follows:

EM2 portable stream table system	$5,850
Color-coded-by-size modeling media	$3,170
Wavemaker	$3,695
Structures kit	$225
Academic kit	$310
Emriver battery adapter	$115
Shipping	$434
Total Geomodel Equipment Cost	$13,799
5-person Request from the STEM Center	**$8,000**
Request from PACE TIG grant (inc. $500 stipends)	$8,300

Over 1,000 students each semester across upper- and lower-level courses will be able to take advantage of this stream table/geomodel being available. As indicated above, given the total equipment costs, our team is also applying for an $8,300 Teaching Innovation Grant (TIG) from the SHSU PACE Center to cover the rest of the equipment and necessary accessories ($5,399), as well as $500 stipends for setting the table up, maintaining it for all of the course listed above, and re-writing some of the labs and other exercises for Spring 2023.

Though we have included the sole-source justification for why we hope to purchase this specific EM2 model to improve active learning and student engagement, Thélusmond et al., (2013) also demonstrate that Little River Research and Design's plastic modeling media performs well at scale by better representing sand and gravel in real-world systems.

Co-PI Statements on How the Stream Table Will Specifically be Used in Courses

David Moss: Assistant Professor and Historical Geology Lab Coordinator
Courses: GEOL 1404 (Historical Geology), GEOL 3330 (Oceanography), GEOL 4400 (Stratigraphy and Sedimentation)
Summary:

Renjie Zhou: Assistant Professor
Courses: GEOL 1405 (Geologic & Environmental Hazards) and GEOL 3326 (Environmental Geology)
Summary: Visualization of geologic phenomena is a critical learning approach to many geoscience courses. The stream Geomodel is readily related to the real word by coinciding with lectures, textbooks, reading materials, slides, satellite images, and topographic maps. It can be used to foster student active engagement and enhance students learning outcomes in several chapters of GEOL 1405 (Geologic & Environmental Hazards) and GEOL 3326 (Environmental Geology), such as chapters of soil, landslides, rivers and floods. A variety of fluvial processes and geologic hazards can be well demonstrated with the stream table. For example, students in GEOL 1405 and GEOL 3326 can work in groups and modify the gradient/slope of the stream table and observe how flow velocity and discharge are affected and what types of the fluvial responses and features they produce. Also, students are able to relate the results of stream Geomodel to their own experience by involving the discussion of flooding problems near streams: students will be asked about the safe areas for flooding and observe if these areas are impacted when the stream is flooded. Other relevant geologic concepts that can be illustrated with the stream Geomodel include, but are not limited to, the principles of erosion, deposition and erosion, and how different streams characteristics and conditions intersect and impact landscapes.

Joseph Hill: Associate Professor and GEOL 1403 Lab Coordinator
Courses: GEOL 1403 (Physical Geology) lecture and lab sections
Summary: The proposed stream table would be very beneficial to our introductory Physical Geology laboratories. The students would be able to model fluvial dynamics, flooding, and various depositional regimes that are discussed in the course. Understanding stream dynamics, sediment deposition, and the cumulative effect of fluvial processes are all important topics in physical geology. Instead of static models of post-erosional fluvial processes, students will be able to actively observe such things as meander movement, active deposition, and sediment transport. Students will also be able to make real-time adjustments to the model to help understand the effects of slope and sinuosity variations in river systems, bank erosion, channelization, and other time-dependent fluvial processes.

Amber Ulseth: Assistant Professor
Courses: BIOL 1401 (Environmental Science), BIOL 3409 (General Ecology), BIOL 5380 (Stream Ecology
Summary: Using a model ecosystem within a laboratory setting to visualize stream functioning will help to solidify stream ecosystem concepts. The proposed stream table will be used for a number of Biology courses, including Environmental Science, General Ecology, and graduate level Stream Ecology. As stream flow is a key component driving and shaping stream ecosystems from physical to biological processes, being able to manipulate flow, sediment structure, and mimic various flow regimes to illustrate how these processes shape stream ecosystems will be helpful from an applied aspect for Environmental Science students to basic concepts of stream power and flow for stream

ecology students. For example, an environmental concern we cover in Environmental Science is sedimentation of stream and river ecosystems. Illustrating the role of sedimentation for major and non-major core students will be useful for understanding the dynamics of this environmental issue. For Ecology and Stream Ecology, we cover the topic of respiration at the stream ecosystem scale. Much of the respiration in streams occur within the sediments. The rates of respiration often depend on the exchange of streamwater with these sediments, which is driven by slope and sediment type. Using the proposed stream table to manipulate these factors would help make the connection between the physical and biological processes of stream ecosystem function.

Figure 1: Photos of the EM2 River Geomodel (courtesy of Little River Research and Design). On top left, a full view of the stream table; Top right, example of modeled stream channel and modeling media; Bottom left, example of academic kit being used for measurements; bottom right, example of proprietary plastic media "sediment" that's 50% the density of the sand and better represents processes in a scale model.

References

Guida, R., D. Moss., R. Zhou, B. Benford, C. Spears, J. Hill, B Cooper, and J.P. Harris. 2022. SHSU's NSF GEOPAths: Where we've been, where we are, where we're going. *SHSU STEM Center Bee Symposium Abstract*.

Holley, E.A. 2017. Engaging Engineering Students in Geoscience Through Case Studies and Active Learning. *Journal of Geoscience Education* 65(3): 240-249.

Huguet, C., J. Pearse, L.F.Noè, D.M. Valencia, N.C. Ruiz, A.J. Heredia, and M.A.P. Avedaño. 2020. Improving the motivation of students in a large introductory geoscience course through active learning. *Journal of Geoscience Education* 68(1): 20–32.

Lillquist, K.D., and P.W. Kinner. 2002. Stream Tables and Watershed Geomorphology Education. *Journal of Geoscience Education* 50(2): 583-593.

Moss, D., R. Guida, B. Benford, C. Spears, R. Zhou, B. Cooper, J.P. Harris, and J. Hill. 2022. Lessons Learned from Two Years of a Summer Program for High School and Community College Students in Southeast Texas. *Geological Society of America Abstracts* 54(5).

Russell, J., S. Van Horne, A.S. Ward, E.A. Bettis III, M. Sipola, M. Colombo and M.K Roceford. 2016. Large Lecture Transformation: Adopting Evidence-Based Practices to Increase Student Engagement and Performance in an Introductory Science Course. *Journal of Geoscience Education*. 64: 37-51.

Thélusmond, J.R., L.R. Chevalier, and B.A. DeVantier. 2013. The use of plastic media in a movable bed model to study sedimentary processes in rivers. *International Journal of Hydrology Science and Technology* 3(2): 93-110.

Wikle, T.A. and D.R. Lightfoot. 1997. The Stream Table in Physical Geography Instruction. *Journal of Geography* 96(1): 23-30.

Summary

We received funding from both the STEM Center and PACE through a Teaching Innovation Grant (TIG). Additionally, COSET and the Department of Environmental and Geosciences provided the remaining funding to order all included components from this proposal. Though the stream table was ordered on the exact timeline proposed, a typo in the email for the purchase order wasn't discovered until the end of April. Once the typo was found, the company was contacted, and they expedited our order with delivery completed on May 18, 2023. At the end of May, PI Guida and co-PIs Moss and Ulseth set the table up in LDB 315. Unfortunately, the semester had ended, and our students from Spring 2023 that we hoped would experiment with the table in April had gone home for summer. Our goals and implementation for future semesters remain the same in terms of using the active learning the stream table affords students in multiple classes. To facilitate widespread use, we are in the process of building a custom portable cart with department funds to move the stream table around LDB and the campus (it will squeak into the elevators by an inch or two). We hope to display the table during Saturdays at Sam and at other recruiting-related events as well.

Materials in Development

We are still experimenting with the table to develop activities, including projects on evolution of river channels and how deposition and erosion change with high and low flow events. We discovered model houses and vegetation were included and can be added to demonstrate floodplain encroachment issues that are far too common in the Houston metro area, thereby facilitating both active and place-based learning. As soon as the table arrived, PI Guida and co-PI Moss also experimented with how transgressive and regressive delta sequences can be modeled based on rising and falling sea level. For this activity, we will instruct students to keep streamflow the same but change the base level (sea level) by manipulating the height of the drain plug. By doing this, students will be able to observe and document the evolution of delta lobes, similar to how the Mississippi River has migrated across southern Louisiana over time.

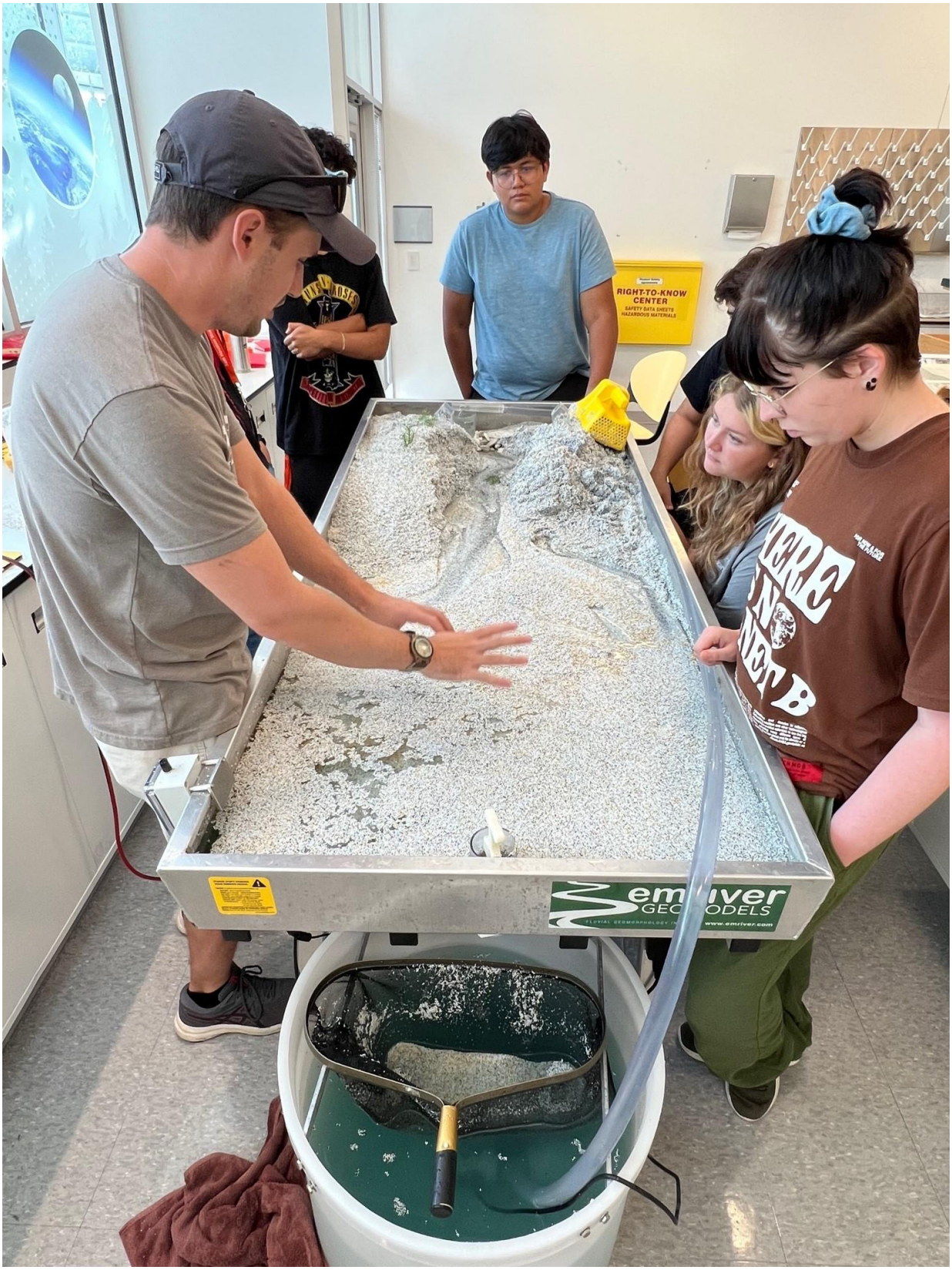
Concluding Thoughts

It is unfortunate that purchasing included a typo in the purchase order, as that prevented us from working with students in April to determine what activities are feasible on a lab timeline and what pilot activities were most promising. We are very thankful that the STEM Center funded the stream table, and we know it will provide numerous benefits to core students, as well as our majors, going forward.

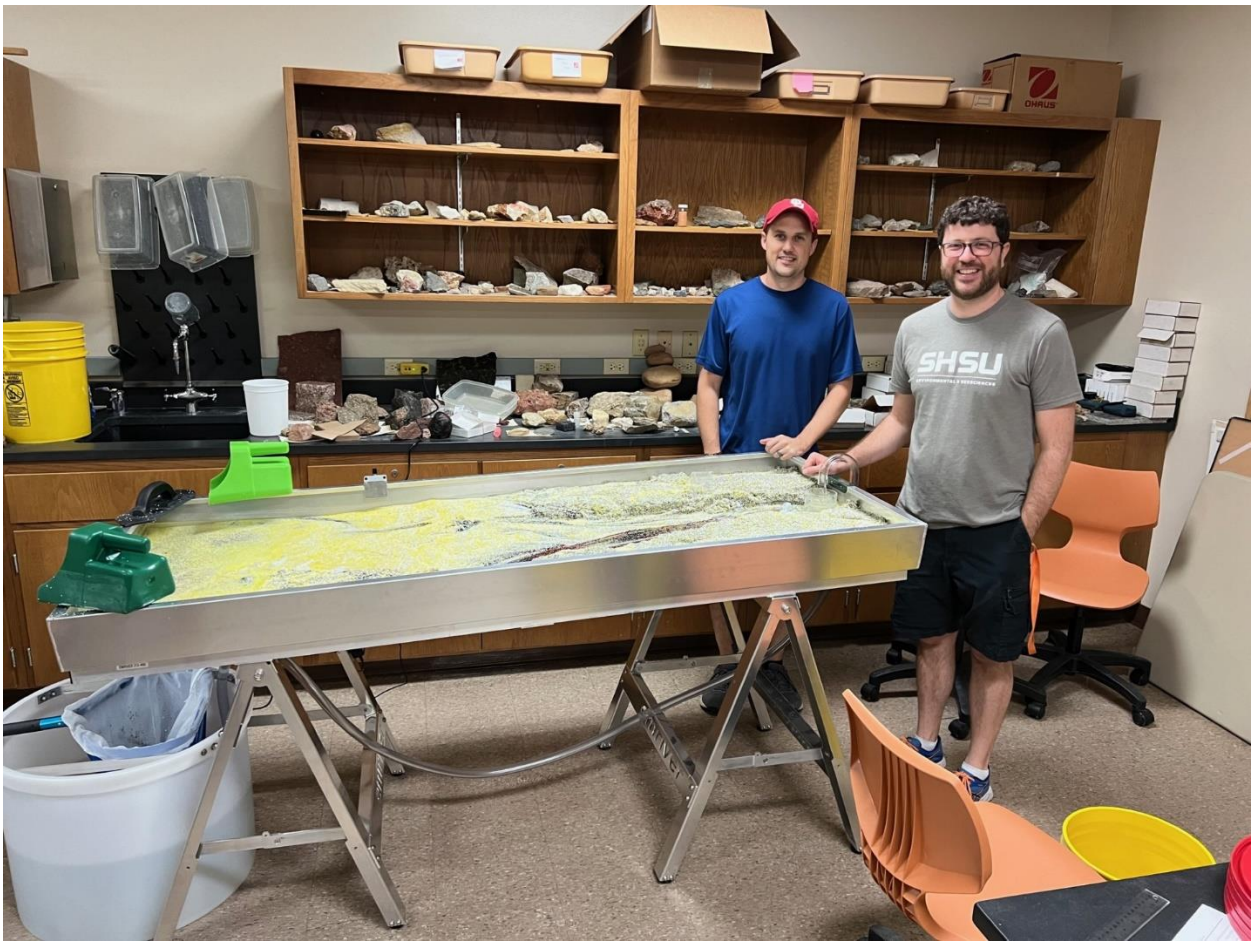
Though the delay in receiving the stream table pushed our timeline back, all of the project participants will be working on making a stream table schedule to maximize use across courses during Fall 2023. Each participant will also be creating their own activities tailored to different learning objectives across class sections and labs. As part of the TIG, the PI will be completing an IRB application late this summer to ask students questions about the impact of the stream table during the 2023-24 academic year. We look forward to seeing results and will include the STEM Center grant in any related presentation and/or publication acknowledgements.

We have included pictures on the following pages that can be used for any STEM Center materials.

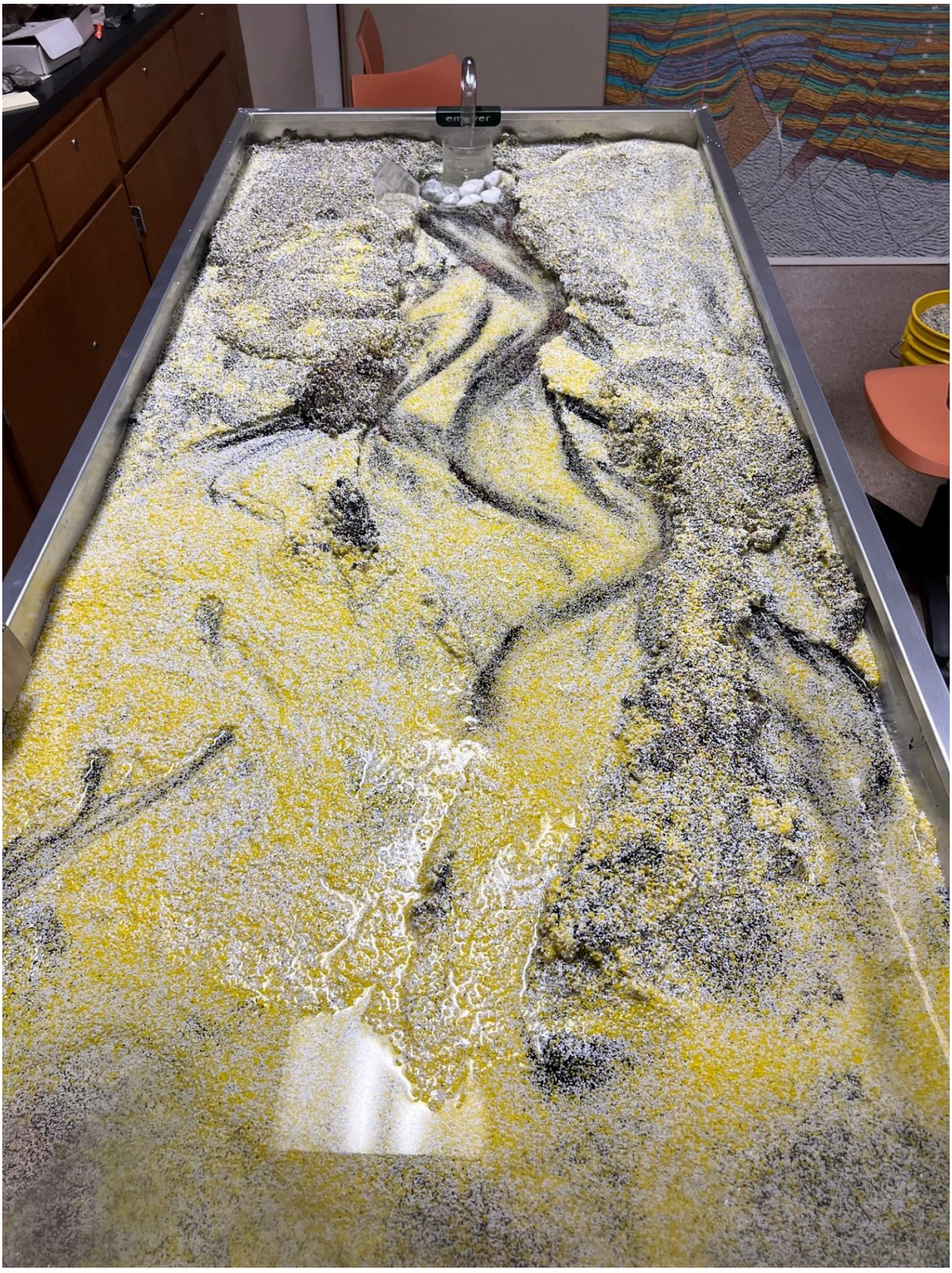
Thank you again for your support!



Students working with an EM2 stream table during the June 2023 GET TX summer bridge program for geoscience.



Stream table setup from May 30, 2023.



Stream table after running on initial setup showing the evolution of the river channel.