

Scientific Life

ChemCarnival: inspiring future STEM pioneers

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Contemporary pedagogical research emphasizes the necessity of outreach events to promote and foster science, technology, engineering, and mathematics (STEM) education. This is vital, both in the Middle East and North Africa (MENA) region and worldwide. Here we describe the creation of *ChemCarnival*, an annual outreach event at the American University of Beirut (AUB) to encourage STEM enthusiasm in the Lebanese community.

STEM research and development drives groundbreaking advancements and solutions that are essential for 21st century problems. Owing to its centrality, departments of education worldwide are constantly devising plans to attract prospective students into the field of STEM. One such program is the 'Raise the Bar: STEM Excellence for All Students' endorsed by the US Department of Education, which seeks to incentivize science education and broaden its outreach to students of diverse backgrounds [1]. Research by Santos-Díaz and Towns highlights that effective outreach fosters a sense of belonging and enhances science communication [2]. Their study further emphasizes that factors such as gender, race/ethnicity, and educational background significantly influence educators' motivations and contributions. It also underscores the role of informal science learning in

engaging underrepresented communities in knowledge exchange [2]. Akrami *et al.* report that STEM education significantly improves skills such as self-confidence, creativity, risk-taking, and leadership [3]. This is buttressed by Rickhaus's [4] recent report on the importance of finding joy in science, which aligns with the goal of quality education in the UN's 2030 Agenda for Sustainable Developmentⁱ [5]. Fitriyana *et al.* extrapolate that the benefits of fortified STEM outreach generally also apply to chemistry education specifically [6].

Despite these promising insights, the persistent negative public perception of chemistry as mundane and challenging remains a significant obstacle. In addition, chemistry and other basic science domains are sometimes viewed as conduits in the pursuit of medical education, with no intrinsic value. These beliefs form an impediment that must be overcome to cultivate true enthusiasm for science education. In the MENA region, these obstacles are even more prominent. Kayan-Fadlilmula *et al.* [7] explain that, while cultural stereotypes and socioeconomic factors are becoming less common barriers for entry into STEM, remnants of their influence still negatively guide cultural attitudes towards the role of underserved populations in science. Interestingly, even when controlling for economic factors (e.g., in Arabian Gulf countries, which are considered resource abundant), students still show a lack of interest in STEM, with little to no research being done to identify what barriers prohibit entry into the field [7]. Thus, allocating financial resources towards STEM education is important but insufficient in fostering an environment of inclusion. This highlights the necessity of further outreach initiatives in generating a cultural transformation towards STEM positivity.

At the AUB, the Transformative Education (TrEd) Program is tackling this issue directly [8]. Through innovative outreach events like *ChemCarnival*ⁱⁱ, TrEd aims to reframe the public perception of chemistry by

presenting it as an exciting and engaging field. *ChemCarnival*, the most extensive STEM outreach event in Lebanon and the MENA region, acts as a vibrant celebration of chemistry by capturing audiences of all ages. *ChemCarnival* aims to redefine traditional perceptions of chemistry through demonstrative experiments, thus portraying chemistry as approachable, engaging, and enjoyable. It is a celebratory festival that not only ignites curiosity and passion for science among students but also fosters an appreciation for chemistry across the broader community, including parents, faculty members, and younger siblings. In particular, the objective popularity of the recent 2024 iteration emphasizes the utility of such outreach events in promoting STEM education and appreciation.

ChemCarnival: a detailed analysis

ChemCarnival has taken place annually since 2017, undergoing a brief hiatus from 2020–2022 due to the coronavirus disease 2019 (COVID-19) pandemic. It showcases the enjoyable aspects of chemistry, making it accessible to both non-STEM and STEM majors alike. It seeks to alter the imposing reputation of chemistry by blending the rigor of scientific experimentation with the mystical experience of witnessing brilliant reactions. The fifth edition of *ChemCarnival* at the AUB marked a significant celebration of chemistry, drawing in over 1000 attendees from across the nation and establishing itself as a prominent fixture in the university's calendar. Under the guidance of the Program Director, students of TrEd (who come from mixed academic backgrounds) organized this event.

The 2024 *ChemCarnival* featured a range of interactive activities, including small-scale experiments like the neutralization of milk, the synthesis of Nylon, the creation of fake snow, and the making of 'elephant toothpaste'. This is in addition to larger-scale experiments, including: the 'Lava Crush' reactions, cloud generation, the paper cannon (using recycled exam sheets), launching

colorful canisters, ping-pong ball rockets and the preparation of liquid nitrogen ice cream (Figure 1). Visual evidence demonstrates the widespread merriment and fascination caused by these highly conspicuous reactions. The combination of kaleidoscopic colors and audience interaction created an impressive spectacle that is clear to see^{iii,iv}. This is in keeping with the goal of *ChemCarnival*, which is to form a sustainable interest in STEM among impressionable youth.

A significant aspect of *ChemCarnival*-2024 was the active participation of AUB's

leadership. The University president, the provost, and the dean of the Faculty of Arts and Sciences personally engaged in the Lava Crush 1 experiment. Their involvement affirmed the university's commitment to nurturing a culture of curiosity and continuous learning, reflecting these values at the highest levels of administration. Their participation provides children with physical role models to emulate (beyond abstract concepts of inclusion), highlighting the event's power compared with typical science programs. *ChemCarnival* transcends the traditional boundaries of a science fair by blurring the boundaries between the

performer–audience and education–entertainment. It serves as a critical tool in inspiring future generations of scientists and fostering a community that values the role of chemistry in everyday life. Hence *ChemCarnival* is in keeping with the broader TrEd goal of 'empowering tomorrow's leaders' [8].

Broader impact: the transformative power of *ChemCarnival*

Ad hoc interviews over the years have highlighted various aspects of *ChemCarnival* and provided insightful perspectives on its impact and appeal^{v,vi,vii}. This often includes



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Figure 1. Collage of photos from the 2024 American University of Beirut (AUB) *ChemCarnival* depicting the experiments Lava Crush, soap splash, cloud generation, flying ping-pong balls, and tossing examsⁱⁱ. The Lava Crush experiment is a large-scale 'elephant toothpaste' version while the soap splash, cloud generation, flying ping-pong balls, and tossing exams experiments are based on a medley of liquid nitrogen and hot water.

its youngest participants, whose testimonies vividly illustrate its transformative power. Attendees describe how *ChemCarnival* shifted their views of science from the mundane to the illuminate. Several participants specifically cited the event as a significant motivator towards pursuing a career in STEM. A common theme among interviewees was a positive change in their previously negative opinions towards chemistry, demonstrating the plasticity in child/adolescent attitudes towards science education.

A wider impact is also found among the AUB student body, whose contributions inspire future generations to consider STEM education in a more favorable light. Parents are also in *ChemCarnival*'s area of effect, providing them with spectacle and inspiration to guide their children towards a new definition of STEM careers.

In 2023 and 2024, the president of the AUB commended *ChemCarnival* for its ability to bring together people of all ages in a celebration of science and creativity and for demonstrating the diverse opportunities in STEM. Complementing this perspective, the provost praised the event for its unique combination of education and entertainment. Involving university leaders in STEM outreach initiatives is particularly useful in that it sends a resounding message of encouragement to the community. Witnessing symbolic figureheads participate in vibrant displays of science tangibly confirms the university's commitment to STEM education. In addition, it allows university management to understand firsthand the necessity of outreach events, by immersing them in a collaboration with students and audiences alike. In so doing, social hierarchy is temporarily demolished, with students realizing the accessibility of science to all people. Chemistry ceases to remain a celestial ideal and instead is brought firmly to the ground.

Preparation challenges and lessons learned

ChemCarnival has left an indelible impact on each member of the TrEd team, showcasing the collective effort that fueled its success. This event stands as a testament to the dedication and collaboration of all team members that was necessary in bringing *ChemCarnival* to fruition. Months of preparation built a solid foundation that allowed the event to be executed without breaches in continuity or safety. Financial planning also had a prominent role throughout the process; securing sufficient funding was critical in actualizing *ChemCarnival*'s ambitious potential. Trial runs of each experiment are conducted annually in advance of the springtime event to troubleshoot for potential safety gaps and elucidate areas of improvement. This includes making small adjustments to pre-existing experiments, adapting new experiments to the AUB environment, and even ruling out some reactions entirely due to infeasibility. This process of trial and error mirrors the scientific method, applying it for the purposes of entertainment and education.

Several variables become relevant on the day of execution, including weather conditions, logistical challenges, and any final modifications to the set schedule. Despite the adversity, peer-led teamwork makes the process of actualization possible. By entrusting students with leadership roles, it nurtures a sense of ownership and responsibility. This approach not only empowers student organizers but also inspires attendees through social learning, making a compelling argument for the transformative nature of the event. Furthermore, the team's rapid adaptability breeds resilience and flexibility, which are invaluable skills for a STEM scholar to possess in their line of research work.

Future goals: expanding our reach and vision

In the long term, the aim of *ChemCarnival* is to ignite a spark of scientific interest

among young minds, in synchrony with other TrEd initiatives such as the Mentoring Talks [9], and to ensure that each year's *ChemCarnival* is more accessible and collaborative than its predecessor. We plan to broaden our outreach to individuals beyond the privileged halls of academia, allowing the message of STEM inclusivity to reach the general population at large, and encourage all those in outreach to strive to do the same. *Prima facie*, it may appear to prospective STEM promoters that emulating such an initiative will be an insurmountable task. Fortunately, experience has demonstrated that this is not the case. With the combination of pedagogically minded educators and motivated students, start-up initiatives at any institution are certainly achievable. Involving upper management and university leaders in this process is key, both in mobilizing potential resources and bolstering the social impact of such events. While the technicalities of each unique outreach program may vary, the essentials as detailed in this article remain steadfast. It is the sincere hope of the authors that STEM educators worldwide will heed this 'call to action' and further our endeavor for years to come.

Acknowledgments

B.R.K. highly values the passion, dedication, and creativity of all members of the TrEd team throughout the years. Funding of *ChemCarnival* by the American Chemical Society (ACS), the American University of Beirut (AUB), and all sponsors is highly appreciated.

Declaration of interests

The authors declare no competing interests.

Resources

ⁱwww.undp.org/sdg-accelerator/background-goals

ⁱⁱwww.aub.edu.lb/ChemCarnival

ⁱⁱⁱ<https://youtu.be/o2LRISjn-0A>

^{iv}https://youtu.be/AlwHeWs_D0w

^v<https://youtu.be/oT6rJPaddTM>

^{vi}<https://youtu.be/FqS8tVsPOSOM>

^{vii}<https://youtu.be/6G7HqL-eiX8>

viii <https://youtu.be/OIEffZo9wto>

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<https://doi.org/10.1016/j.trechm.2024.08.001>

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