Rock-Slide: Climbing Volume with Linear Actuation

The Transition of Climbing from Outdoor to Indoor

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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General Research Problem:

What conditions of indoor climbing have increased its popularity compared to outdoor climbing?

Rock climbing as a casual activity has been growing in popularity in the last 10 years, with climbing gyms popping up all over the place, a climbing documentary winning an Oscar, and more and more people checking out the climbing gym like you would go bowling or roller skating with your friends. Originally climbing gyms began to help prepare for outdoor climbing on real rock, and while that is still the general idea there are many people nowadays who climb in gyms that may never climb outside. Demand for indoor climbing gyms is at an all-time high, within the last decade in the US the number of climbing gyms has more than doubled (Climbing Business Journal, 2021). In order to help my reader better understand the relationship between humans and nature, I will study the relationships between indoor and outdoor climbing gyms, because I want to find what has contributed to indoor climbing's rise and the effects of it on who participates in the sport. In examining outdoor climbing, I will investigate how each discipline of outdoor climbing effects the environments they take place in, including traditional and sport climbing, big wall climbing, mountaineering, and bouldering across the world. I will consider the history of outdoor climbing technology and techniques and how they shape man's interactions with nature. Finally, I will consider the impact of indoor climbing gyms, their popularity and relationship to outdoor climbing.

Indoor climbing gyms initially tried to recreate a very similar experience to that of outdoor climbing, with the style of climbing representative of real rock and even holds and walls made to look like rock. In more recent years, as indoor climbing has gained a culture of its own, indoor climbing has taken on a completely different form over outdoor climbing. All kinds of strange movements and gymnastic-like maneuvers are commonplace with indoor boulders and rope climbs that would not exist in nature. Pushing this idea further, my capstone group decided to develop a moving climbing hold to further push the envelope. This manifested in the form of an aluminum frame supporting a plastic climbing hold that will translate linearly depending on how the frame is mounted.

Technical Research Problem - **Rock-Slide: Climbing Volume with Linear Actuation**

Like any other sport, technology in climbing has been steadily evolving since the advent of the sport. Formerly, iron spikes with a ring on the end, called pitons, would be hammered into a crack of the rock to tie rope to. Nowadays, there are hammer drills specifically designed to dig through the rock so a more secure bolt can be placed. This is then utilized by another piece of technology developed after pitons – carabiners. Permanent bolts can have "quickdraws" attached, two carabiners connected by a semi-rigid material, so climbers can clip in their rope as they ascend. Where climbers do not want to place permanent gear, and have a crack to ascend along, they can place a spring-loaded camming device which will expand to fit the crack. The majority of large climbing technology advancements have been in the name of safety and easier ascension for outdoor climbing on real rock.

Indoor gyms, however, have also seen their fair share of advancements. Since these gyms serve the purpose of being a place to train on a regular basis, when trekking outdoors to climb regularly is not very efficient, there are a number of devices that emerged to improve the training experience. Static training devices such as hangboards and campus boards evolved to help train aspects of grip strength and explosive upper body strength. Hangboards act similarly to a pull-up bar but is instead an array of holds of varying depths to train finger strength by performing dead-hangs, pull-ups, or various other exercises. Campus boards are training devices in the form of a ladder of holds, typically wooden rungs, designed to train vertical moves without using one's feet. Auto-belays often relay on hydraulics or magnets to allow a climber to descend a wall safely without the need for a person belaying them. In recent years a number of companies have developed small climbing walls with an array of climbing holds that will light up with LEDs at each hold indicating to the climber which holds are in play for a selected route. These walls are standardized, and thus routes that anyone can set can be shared across the world.

My capstone group wanted to develop a device that can be in any indoor climbing gym, specifically with the UVA Slaughter Recreation Center Climbing Gym in mind, that would bring a new aspect to climbing unseen in any other existing training device. From brainstorming, my capstone group converged on the idea of creating a truly dynamic climbing hold. This manifested in the form of a climbing hold supported along linear guide rails and driven by a DC brush motor. Bouldering walls feature an array of 3/8-inch diameter screw holes for climbing holds to be mounted, so we designed a slotted mounting plate to allow for near-continuous mounting options. This plate is on the back of a trapezoidal prism built of 1-by-1-inch square 1/8-inch aluminum walled tubing, with tubes running length wise along the top and bottom faces of the prism to support the mechanism. The mechanism itself consists of a flange on a lead screw supported by two pillow block bearings, then coupled with a DC brush motor. When the screw is turned, the flange moves along the screw. The DC brush motor features a worm-gear transmission to multiply the motor's torque, as well as providing useful feature of preventing the screw to spin when not powered. The flange has attached a shaft screwed into three linear guide rails to support the weight of a climber hanging from this shaft. At the end of the shaft is a wooden hold mount on which any regular-sized climbing hold can be mounted. This project involved many aspects of mechanical engineering, including computer aided design, 3D printing, computer aided manufacturing, finite element analysis, and mechatronics. Throughout the mechanical engineering curriculum, there have been plenty of opportunities to practice and try out techniques we have learned, but there has never been the chance to design and build something from the ground up. This project required an iterative design process that requires many of the design methods and fabrication techniques we have learned over the past years.

STS Research Problem – The Relationship Between Indoor and Outdoor Climbing

I would like to investigate the historical relationship between the sport of climbing outdoors in nature and its artificial counterpart taking place in indoor climbing gyms. Outdoor rock climbing is a broad term for what encompasses many different disciplines, including but not limited to, sport climbing, traditional or "trad" climbing, bouldering, big wall climbing, and mountaineering. In examining the history and of outdoor climbing and its influence on indoor

climbing, I will be limiting myself to these disciplines. Sport climbing is climbing relying on permanent anchors in the rock on which protective gear can be placed for when the climber ascends. Trad climbing requires the climber place gear entirely on their own as they climb, which limits the gear to that which can fit in cracks, be it nuts, a piece of metal to be jammed in a crack, or a much more complicated spring-loaded cam that will expand to fit a crack. Bouldering is climbing taking place on smaller formations without the use of roped protection. Big wall climbing involves climbing large cliff faces, consisting typically of trad climbing, where climbers may spend hours ascending and may even sleep on deployable hanging cots called "portaledges". I will be including climbing from all around the world, as it is a truly international sport and participants of the sport often travel to climb or try to climb when abroad for other reasons. Camoletto and Marcelli (2019, p. 34) have rock climbing defined truly as a "nature sport" as nature plays a significant role and involves nature not shaped by humans. The authors focus in their paper on the "indoorization" of climbing, on page 40 discussing how indoor climbing began as training for mountaineering, but the increased popularity of the indoor gyms began the "sportivization" of climbing and "(promoted) a shift to competitive sports events" (p. 41). I will examine the role indoor climbing has on the sport, bringing more people away from sensitive nature and into the structure of indoor climbing.

Outdoor climbing most often occurs outside the confines of human civilization and therefore requires those interested to trek out into nature. Sport and traditional climbing, as well as the more extreme mountaineering and big walk climbing involve scaling cliffs, while bouldering is only on boulders and small rock faces near the ground. Each discipline presents their own unique disturbances to nature, with little opportunity to be avoided. Depending on the location and style of climbing will determine how climbers can affect the flora and fauna. Bare sandstone will likely lack plants and animals to disturb, but plenty of environments are much more susceptible. Cliffs that are home to different species of bird may attract climbers that will alter the behavior of those birds (Covy, Keeley, H., & Benedict, 2020, p. 245). Other cliff-dwelling creatures such as rodents and reptiles typically will not enjoy a human disturbing their habitat. Chalk left by climbers on the rock can hurt plants if it alters the pH of their environment (Hepenstrick, Bergamini, & Holderegger, 2020, p. 11363). Susceptible lifeforms include moss and ferns which will grow on boulders in popular climbing regions such as Fontainebleau or Frankenjura. Climbers sometimes will have to remove dirt and plants from crevices in the rock in order to free up a handhold or perhaps a spot to place their gear. Bouldering brings up another issue, with that being the extended presence of humans in the area around the boulder as they project their problem. Climbers may spend hours each day for many days hanging around a rock and this extended presence is likely to damage the plants in that area. Sometimes debris that is home to plants and insects may be removed to clean up a boulder, or limbs from a tree removed to allow an ascent. Boulder pads must be placed below a boulder to allow a safe landing from a fall off the boulder, and this can destroy plants that they are placed on (Van Der Mewre & Joubert, 2014, p. 230). Another aspect to consider is to research the effects of hiking on the environment as it factors into the overall picture, as often climbers must hike to their destination. Camping can also be taken into consideration as an avenue of environmental harm caused by climbers.

A brief history of climbing technology was discussed in the technical research section above and is something I would like to explore further. I would like to examine how advancements in climbing technology has affected participation in indoor climbing over outdoor, as well as benefits in climbing gear on making ascents easier and less impactful on the environment.

I would like to collect articles analyzing the rise of indoor climbing, the causes as well as the implications. I will examine the environmental impact of different aspects of outdoor climbing, and how indoor climbing can reduce this. This will include articles for both traditional climbing, sport climbing, and bouldering. I would like to find articles for the effect on both plants and animals, be it destruction of habitat or even change in behavior. I intend to find statistics on indoor versus outdoor climbers, and perhaps articles about the trend towards indoor climbing. Historical sources will play a key role in providing insight about how opinions of outdoor and indoor climbing have changed, as well as providing information about the history of climbing technology. This can include climbing magazines, documentaries, and press releases regarding new technology. I want to look at all sides of climbing, including how far individuals may travel for climbing, how hiking impacts the environment, and camping. I may find success in looking for articles specifically about fragile environments, where climbers may trek to find new routes. This could include rainforests, or perhaps the tundra where plants may have only a few weeks throughout the entire year to grow and trampling plants could be undoing years of growth. Statistics on indoor and outdoor climbing participation by race, ethnicity, gender, and socioeconomic status will play a key role in drawing conclusions about the success of indoor climbing and its reach to communities not typically associated with climbing.

Conclusion

Rock climbing began as a quintessential nature sport, but over time has evolved to extend to completely artificial climbing environments, through technology and limitations of nature. Devices used in outdoor climbing have ensured better safety and ease, while indoor climbing devices have improved the training landscape. I hope to be able to show all sides of the sport of climbing – both indoor and outdoor, aspects of outdoor climbing that may attract climbers or send them to the more controlled indoor climbing environments.

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