LiftSmart: An Accessible Platform for Safe Weightlifting Practices

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1 Introduction

With the growing prominence of "fitness culture," fitness-related injuries have been on the rise for years, and are still prevalent today. According to data from the National Electronic Injury Surveillance System (NEISS), from 1990 to 2007, nearly one million Americans went to emergency rooms due to weight-training injuries (Bakalar 2010). This issue is still occurring decades later. A 2023 survey found that 27 percent of participants reported at least one weightlifting injury in the previous six months (Bukhary et al. 2023). While some of these injuries may stem from unrelated factors, many can be attributed to a lack of knowledge about proper lifting forms, the use of excessive weight, malnutrition, and overexertion.

Our project goal is to alleviate these factors and provide accessible and comprehensive education about the gym. There is a tendency for both beginners and experienced gym-goers alike to shy away from asking for help for fear of embarrassment. Instructional images on gym equipment merely demonstrate a vague overview of proper exercise techniques, with lifters putting their body on the line as they experiment to find the correct way to perform a lift. A comprehensive platform explaining each lift would effectively reduce uncertainty and promote safer workout practices, all while empowering users to be confident in the gym.

2 Background

The first paper we examined utilized ultrasound and motion capture technology to analyze foot kinematics while the subjects walked (Telfer et al. 2014). These types of technologies have the upside of being highly accurate because they help minimize visual noise created by soft tissue while being able to highlight skeletal movement in the foot. However, its main pitfall is the complexity of the setup. The technology is bulky and invasive, and therefore not necessarily suitable for a workout environment in its current form. To adapt a technology like this, we would need to be able to miniaturize the technology. The next paper we examined used a Microsoft Kinect camera to measure the angles of joints during a squat (Schmitz et al. 2015). This technology is very simple and has a small form factor, so it is better suited for a gym environment and it's relatively cheap. However, it is limited in its accuracy of measuring angles precisely, which could be problematic because even minor deviations in joint angles can impact how an exercise impacts someone's body. Therefore, we could potentially use this technology as part of our technology stack for rough measurements or use a comparable technology that's more fine-tuned in our learning environment. The third paper we examined used a camera to record subjects and used computer vision and machine learning to analyze the footage to determine the subject's body shape and pose (Ghezelbash et al. 2024). This information could then be used to do a biomechanical

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analysis that could determine the spinal load and determine the levels of flexion or extension in the spine. This sort of technology could be very useful to our project design because it simply requires a camera in terms of physical components, so it has a small physical footprint. In addition, the ability to analyze spinal loads is a crucial part of preventing back injuries, so we'll likely integrate that component into our learning environment, too. The fourth paper discussed wearable DorsaVi IMUs to examine lumbar flexion while performing lifting tasks (Chang et al. 2022). This technology would work for a gym environment because it is a simple wearable technology that's not necessarily overly invasive and it can give real-time feedback. However, the sensors can be a bit inaccurate when performing multi-plane movements, so they may not be suitable for monitoring exercises with a large range of motion. The final paper we examined used physical markers and a motion capture system to record subjects deadlifting and used music to give real-time feedback on their form (Lorenzoni et al. 2019). From this, our group could potentially take the component of live, auditory feedback to use in our own learning environment. However, the use of music specifically as the method of auditory feedback may not necessarily be the most effective way of communicating with the user, so we'll likely use a different form of auditory feedback.

In addition to these technologies, we also examined five differing learning environments. These were (i) Scratch, a block programming platform, (ii) BrainPOP, an educational learning website, (iii) Kahoot, an interactive gamified learning website, (iv) Ed Lessons, a learning platform that hosts a variety of videos and quizzes on specific learning topics, and (v) Stronglifts.com, a website with many exercise guides and workout design guides. From Scratch, we can take the idea of breaking down complex ideas into simpler ones such as explaining the individual components of more complicated compound lifts. We can also take inspiration from its use of an online forum in our own learning environment so that users can help each other learn through interactions with one another. From BrainPOP and Ed Lessons, we can take the use of division of subjects into topics and the inclusion of videos for those topics. For instance, we can make sections for different types of lifts and include instructional videos for each lift to demonstrate how to perform each one. From Kahoot, we can take the deployment of rapid feedback and incorporate that into our learning environment design. Specifically, we want to give users live feedback during their exercises or immediately after the completion of an exercise. Finally, from Stronglifts.com we can take the use of written descriptions paired with videos to give a comprehensive way to explain how to perform lifts.

3 Research and Design Process

3.1 Preliminary User Study

By creating and examining our learner research affinity mapping, we observed users' fitness goals, experiences, and challenges, particularly around strength training and avoiding injuries. Many users are motivated to improve in different areas—some discussed wanting to lift heavier weights, while others want to run faster or get stronger overall. However, a common struggle almost all face is maintaining the correct form during exercises, which has often led to injuries such as shoulder, knee, and back pain, and have become major setbacks that prohibit users from reaching their goals. Many of our users mentioned learning to lift weights in informal ways, such as through high-school sports or from watching videos online. For example, one person learned during high school football, where the focus was more on lifting heavy than on using proper form. Others picked up techniques from social media or friends, which sometimes led to bad habits or poor form. These early experiences have left many users with a basic understanding of lifting but without the technical skills needed to stay safe and avoid injuries. Because of this, some users say they still struggle with pain or form issues, even years after they first started working out. One interesting trend we noticed is users' willingness to use technology to improve. Many of them are open to using their smartphone cameras to get real-time feedback on their exercise form. This shows that users are aware of their limits and want tools that can help them fix their form on the spot, without needing to go to a trainer. They believe that an app or tool like this could help them avoid injuries and make progress toward their fitness goals more safely. This interest points to a real need for easy-to-use tech solutions that focus on injury prevention and form correction, especially for people who don't have access to personal trainers.

3.2 Design Requirements

Our initial implementation had three main design requirements: first, a learning portal where users could explore the world of lifting education and learn new exercises at their own pace. We derived this design requirement from Sugata Mitra's concept of self-organized learning environments - where students can learn more without supervision. To prevent learners from becoming overwhelmed by an influx of information, the Learning Portal also recommends new exercises for users to learn based on their prior data.

Our second main design requirement was some sort of feedback to evaluate the learner's lifting form. We first decided on the integration of a computer vision-based model where a learner could record and upload or live scan a video of them performing a lift, and receiving either immediate formative feedback from the live scan mid-lift, or summative feedback from uploading a video.

Third, we wanted to include a social aspect to LiftSmart, to allow users to learn collaboratively. Based on Lev Vygotsky's sociocultural theory, we included features that allowed users to connect and chat with friends, real-life personal trainers, and other members at their gym. This would allow users to plan workouts together, receive feedback from trainers, or in general, feel included in their gym community.

3.3 Preliminary Design

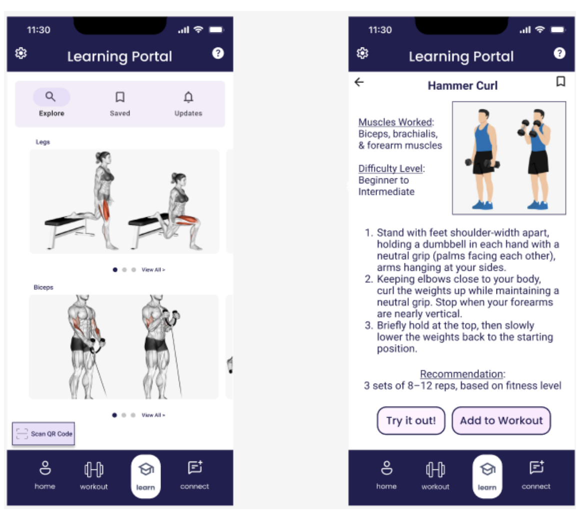
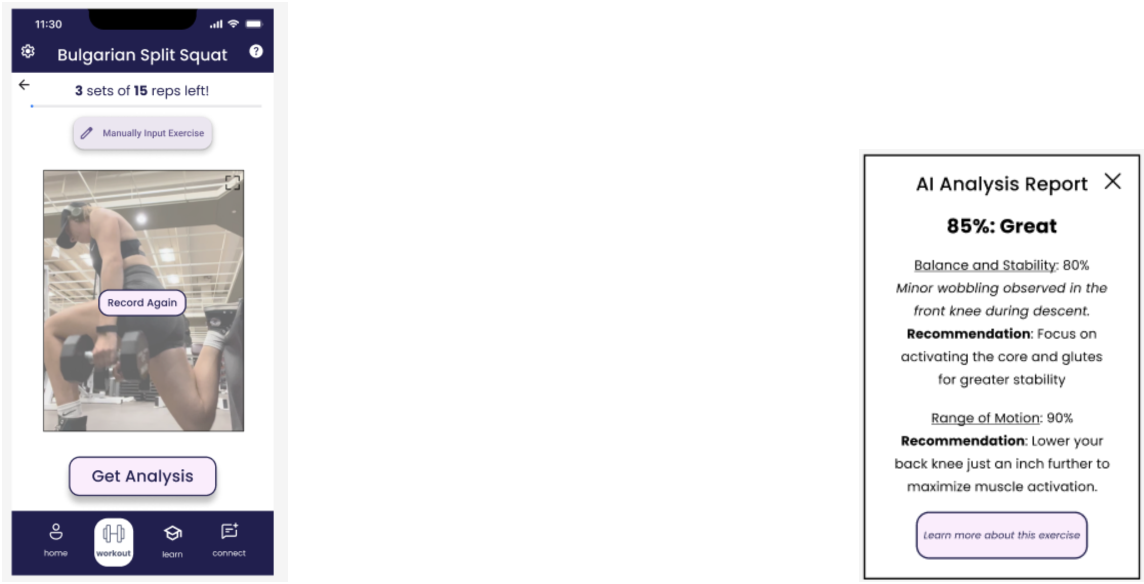


Fig. 1. Learning Portal, where users can view recommended and new exercises. Users can select and exercise and get a full breakdown of how to perform the exercise.



(a) (b)

Fig. 2. Users can record their workouts and receive an AI Analysis Report providing feedback on their form.

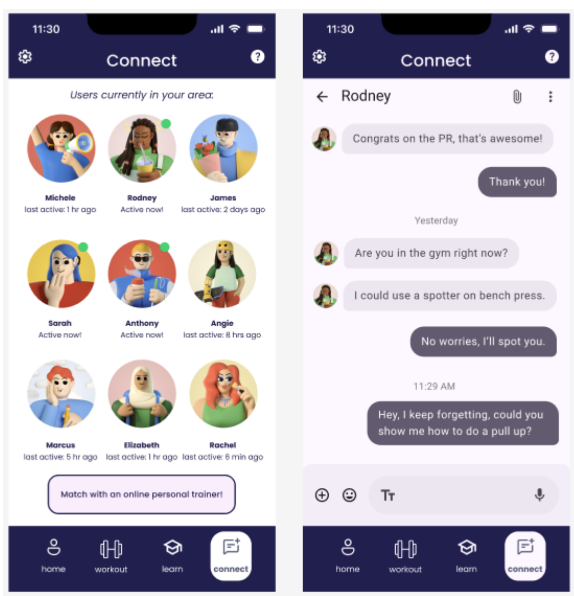


Fig. 3. Learning Portal, where users can view recommended and new exercises. Users can select and exercise and get a full breakdown of how to perform the exercise.

3.4 Design Updates

During user testing on our initial design, our test users pointed out that LiftSmart doesn't inherently provide any motivation for users to continue using the app, and rather relies on the motivation of each user as an individual. They expressed a desire for gamification aspects that encourage users to continue using the app each day. As a result, we updated our design to include a rewards system, which grants users both intangible and monetary prizes for each milestone they reach on the app. We also implemented a community leaderboard for each workout to induce healthy competition. Users gain points for each new exercise and workout they complete. With these points, users can collect intangible rewards such as badges for each achievement they accomplish, as well as real, monetary rewards offered from partnerships with athletic companies and brands. Our final design can be found here: https://shorturl.at/WCdjl

3.5 Summative Evaluation

After finalizing our design, we conducted a final round of user testing. We included both previous and new users. We found that the Learning Portal was one of the greatest successes of our project. It offers structured, user-centered guidance, and our users agreed that this would be a useful tool for them in their daily workouts. In addition, our test users cited that the integration of AI feedback for exercise forms and a connect page for community interaction went above and beyond in supporting their diverse needs, thereby reducing barriers for beginners and promoting long-term engagement. Our integration of gamification provides users with a sense of motivation and competition, encouraging users to continue to learn and grow in the gym. Ultimately, throughout this project, we learned about the process of creating a solution to better the lives of others. We conducted a thorough investigation into the problem, designed multiple versions of a prototype, and evaluated the proposed solution with real people.

4 Discussion

4.1 Key Takeaways

Throughout the time we spent working on this project, we came away with a few key takeaways: First was the genuine importance of constantly keeping a sociotechnical perspective during our design process. We considered using different technological platforms for LiftSmart - including VR/AR/XR designs. However, we found that these fancy technological platforms would not provide a better learning environment than a simple mobile app - and would simply be using technology for the sake of using something fancy.

Our second key takeaway is that a learning environment is never dependent on one single learning theory. In class, we learn the theories one by one. However, when designing a fluid and effective learning environment, it is important to apply the principles of multiple different theories and aspects of learning. Using this takeaway combined with our novel project idea allowed us to make LiftSmart into something brand new that other applications in the fitness industry have not done.

4.2 Connection to ACES

Accessibility: Our design promotes accessibility because it provides resources for all levels of lifters from beginners to veterans to improve their performance and knowledge of lifting. This is done through comprehensive guides that teach lifters how to perform exercises and feedback given for exercise forms from our app's AI and the app's community.

Collaboration: Our design promotes collaboration through the implementation of the "connect" section of our app. This section provides a forum for gym-goers where they can communicate with other people about their progress in the gym and get feedback on gym-related things such as exercise form, workout planning, etc.

Embodiment: Our design promotes the idea of embodiment because the nature of exercise is inherently physical. More specifically, in use cases where individuals are trying to improve their form, they need to physically perform the exercise and record it, so that it can be uploaded and critiqued for feedback.

Sustainability: Our design promotes sustainability because of the nature of several components of the app. First, our guides for how to perform an exercise will not need to be updated since the definition of "proper form" is very static so these will not need to change. Furthermore, there will always be people who need to learn how to perform exercises and improve their form, so this app will always be relevant. Our app is also environmentally sustainable being that it's an app, so it requires no physical resources and thus does not impose any sort of environmental harm.

4.3 Limitations and Future Work

While we believe that LiftSmart is a comprehensive platform, it is not without its limitations. The main weakness we identified was that to receive feedback, a user would have to set up a camera or their phone to record themselves. We found that new gym goers would likely feel awkward, or even scared, to setup a tripod or camera in the middle of a public gym.

In the future, there would definitely be many features that we would have liked to include. First, one future idea we considered is creating a social network within LiftSmart. Social media is a powerful way to keep users engaged, hence we could implement a similar concept as TikTok and Instagram Reels, where users could scroll through a tailored feed of entertaining fitness pictures and videos. A second feature that could be added would be a status indicator indicating how busy a gym is at the moment. New gym-goers often feel overwhelmed and awkward when a gym is packed. Including this feature would allow users to find a time that would be best for them. This could be implemented simply by comparing the number of active users at a gym versus the average amount of users.

A Team Contributions

All team members contributed to brainstorming with different design ideas and conducting user testing, as well as contributing to the P1, P2, and P3 milestones. Maddie, Kenny, and Jalen focused on creating the poster while JayaSai and Andrew focused on writing this paper.