Engineering Leadership development is essential for modern industries. However, due to cost and inefficiency, traditional engineering leadership development does not seem very effective. The failures of traditional leadership development can be attributed to the absence of embedded leadership development among engineering professionals and the challenge of applying the right leadership strategies in the right contexts. Despite the encouragement of enhanced leadership development, many studies lack an examined framework, especially when it comes to leadership development for undergraduate engineering. In this research effort, the impact of 3D virtual simulation on enhancing the leadership abilities of engineering students, at both the individual and team levels, is based on a framework that carefully incorporates utilizing SWOT analysis (strengths, weaknesses, opportunities, and threats), the Matrix of Change (MOC - based on Total Quality Management (TQM) House of Quality), and the Balanced Scorecard (BSC) to the virtual leadership environment design planning process. In this developed framework, the virtual simulation was used to provide experiential learning by replacing human beings with avatars that can be managed or dramatized by real people. This framework has been examined and validated by a randomized pretest-posttest control group design. Paired t-test has shown a significant development in the average team leadership skills in the experimental group while no significant change occurred in the teams of the control group. Similar results were noted by using two-sample t-tests when both experimental and control group were evaluated. There is a reduction in the mean of individuals' test which indicates there is a small enhancement in the individual's leadership skills, but that change is small and not statistically significant. It was found in this exploratory study that administration of 3D virtual leadership simulation on the undergraduate engineering students had a significant effect on the team average leadership skills. These results can enable engineering managers to create live, practical, measurable, and customizable leadership development programs. The research has great insights that might assist engineering programs to improve curricula for the purpose of better engineering leadership preparation to meet the industry's demands.