Abstract Social Learning Particle Swarm Optimization (SL-PSO) greatly improves the optimization performance of PSO. In solving complex optimization problems, however, it still has some deficiencies, such as poor search ability and low search efficiency. Hence, an improved SL-PSO, namely, Three-Learning Strategy PSO (TLS-PSO) is proposed in this paper. Firstly, a med-point-example learning strategy and a random learning strategy are proposed to replace the imitation component and social influence component of SL-PSO to enhance the exploitation and exploration, respectively. Secondly, the two learning strategies are combined cleverly into an updating equation to balance exploration and exploitation. Finally, a worst-best example learning strategy is merged skillfully to construct TLS-PSO with hybrid learning mechanism and further enhance the search ability. The experimental results on the complex functions from CEC2013 and CEC2017 test sets indicate that TLS-PSO has better performance compared with state-of-the-art PSO variants and other algorithms. For example, TLS-PSO has an advantage over SL-PSO on 50 of the 56 functions from CEC2013, its running time is less than SL-PSO’s and it has higher search efficiency. Simulation results on the 10 engineering problems also show that TLS-PSO outperforms 7 excellent algorithms, such as IUDE and iLSHADE𝜖. It is expected to solve practical problems better.