On one hand, Hurley’s five-level continuum focuses on the teaching and learning of science and mathematics, in which forms of integrating these two subjects ranges from sequential (one after the other) to total (the two considered major) through parallel (simultaneous teaching), partial (partially teaching of the two), and enhanced (one taught as a major discipline with other supporting). On the other hand, Jacobs’ six levelled frame embraces all the four STEM disciplines and begins with a disciplinary level discipline-based (separate subject teaching) and moves to parallel (connected through the same themes/topics), multidisciplinary (two or more disciplines taught together), interdisciplinary (deliberately making connections between/among disciplines), integrated (connected through real-world problems), and total integration (infused into a totally new discipline). Both Hurley and Jacobs provide evidence that the development of STEM competencies is largely achieved in total integration.

Other frameworks for integrated STEM education provide how its theoretical models can be put into practice or implemented. For example, the National Academy of Engineering and National Research Council (2009) frames integrated STEM education within four features, that is goals, nature and scope, implementation, and outcomes. These features can be connected into an implementation process that starts with defining goals of integrated STEM education and ends with outcomes. The goals define the development of 21st century competencies (Fig. 1) as one key purpose of STEM education which is to be evident as an outcome. These goals are pursued through selected STEM integration models within the nature and scope stage. At the implementation stage, the selected model informs the pedagogy to be used within a supportive context.

Several pedagogical perspectives of STEM education that can be adopted or/and adapted exist in literature. These are inclusive of collaborative and cooperative learning and engineering design (Li et al., 2020; Thibaut et al., 2018); gamification/games and social media learning (Chu et al., 2017), problem-based learning, project-based learning (Connors-Kellgren, Parker, Blustein, & Barnett, 2016; Fidan & Tuncel, 2019; Parno, Yuliati, Hermanto, & Ali, 2020), constructionism (Chu et al., 2017; Enneking et al., 2019), and virtual reality and augmented reality (Chu et al., 2017; Concannon, Esmail, & Roduta Roberts, 2019). Within each pedagogical approach are commensurate activities that can be designed to foster student-centred learning. For instance, in constructionism students engage in activities such as creation of complex computational digital artifacts, collaboration and sharing, expression of deep conceptual knowledge, and the use of information resources in workshop-based environment-hybrid laboratories (see Chu et al., 2016).

The literature also suggests that total integration occurs in supportive contexts. In this chapter, the descriptions of supportive contexts are drawn from authorities like Nadelson and Seifert (2017) who note that innovative STEM teaching and learning occurs typically in environments that allow students to solve real-world problems. Contexts for the implementation of integrated STEM education are both theoretical and tangible. A theoretical context as noted by Kertil and Gurel (2016) is a STEM problem-based learning (PBL) that consists of interdisciplinary learning objectives, ill-defined tasks, student centred interactive groupwork, collaboration and other design activities. Sujarwanto, Madlazim, and Sanjaya (2021) provide that the “need to know” theoretical context arises when the principles and theories used are insufficient to solve a problem. The other theoretical context is the “need to do for engineering”, which implies the process of designing and testing a product, which requires the use of principles and theories related to materials, processes and energy.