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The effect of gender composition and pedagogical approach on major and non-major undergraduates biology students' achievement

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ABSTRACT

This study hypothesized whether the gender group composition in traditional learning (TL) versus collaborative learning (CL) classrooms of undergraduate biology majors and nonmajors correlate with students' achievements. We measured the effect on gender and the gender-specific achievements of the TL versus CL approach in single-gender and mixed-gender classes. A significant gender gap was found in the achievements of both nonmajor and major students. Females achieved higher grades in TL and CL sections in single-gender classes; overall, academic achievements between females (F) and males (M) demonstrated a significant difference at $P < .05$. The effect size value between TL versus CL indicated that males benefited more than females implementing CL mixed-gender (2F+2M) in nonmajors and majors. While females in single-gender CL and TL classes performed higher than males, females performed relatively low in mix-gender CL (2F+2M). These findings indicate that gender-specific and context-specific learning pedagogies are required since they impact students' achievement.

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1. Introduction

In recent years, the changing ecology of the science education landscape has heightened the need for culturally and contextually responsive and highly effective teaching approaches to provide equal opportunities to achieve higher learning outcomes (Kalolo, 2015; Prins et al., 2018). Widening gender disparities are critical issues in introductory biology classrooms and more severe in dominant male societies that need further research to develop learning strategies to equalize opportunities for all students (Eddy et al., 2013; Eddy et al., 2014; Freeman et al., 2014). Introducing controversial topics and integrating new pedagogical approaches to different cultures is a challenge that science teachers face while teaching science in a religious culture or multicultural society (Almasri, 2022a; Mansour, 2008; Reiss, 2005). Considering every culture holds its own set from standards, requirements, challenges, and sociocultural aspects that shape its identity, what works in one country may not necessarily work in another (Hewapathirana & Almasri, 2022; Mansour & Al-Shamrani, 2015; Wang & Degol, 2017). There is an emphasis on students' gender in selecting learning

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strategies to reduce the negative influences of social identities and stereotypical threats in different sociocultural contexts that widen the gender gaps and gender segregation (Belenky et al., 1986; Cavallo et al., 2004; Cavallo & Laubach, 2001; Galotti et al., 1999; Severiens & Ten Dam, 1994; Severiens & Ten Dam, 1998).

Eddy et al. (2013) emphasize that we have gone far beyond enrollment issues; now, we are facing new challenges related to gender inequality in science education in various sociocultural contexts that require more in-depth research to surface underlying root causes, conflicting gender identities and sociocultural factors (Beasley & Fischer, 2012; Cech et al., 2011; Eddy et al., 2013; Eddy & Brownell, 2016; Kalolo, 2015; Kim, 2002; Mihut et al., 2017; Riegler-Crumb et al., 2012). The severity of lower academic achievements and retention of females in biology careers has been portrayed in the leaky pipeline phenomenon, thus drawing attention to providing equal opportunities for all genders to ensure merit-based achievements, retention, and career success (Eddy et al., 2014; Hewapathirana & Almasri, 2021; Lauer et al., 2013; Moorosi, 2010). Numerous gender disparities, widening achievement gaps, female's lower-class discussion, class group participation, and continuous underachievement as they receive lower grade points in introductory biology classrooms remain critical issues in many contexts, and most of them are still under-researched areas (Bailey et al., 2020; Lauer et al., 2013; Lauer et al., 2019; Rauschenberger et al., 2010). Besides biology nonmajor and major female and male students' differences in knowledge, learning styles, and achievements, it is unclear about the effects of various social and gender identities and pedagogical approaches on biology students' achievements due to a shortage of research (Crossgrove & Curran, 2008; Knight & Smith, 2010; Sundberg & Dini, 1993).

Research on various teaching pedagogies discusses the possibility of enhancing students' achievement in biology classes and reducing the gender gap by implementing collaborative action-oriented teaching pedagogies (Bruffee, 1981; Laal et al., 2012; Le et al., 2017; Petrescu et al., 2018; Scager et al., 2016). The effectiveness of collaborative learning (CL) against traditional lecture-based learning (TL) pedagogies was investigated in biology classes (Almasri, 2022a; Arcila Hernandez et al., 2021; Eddy et al., 2015; Eddy & Brownell, 2016; Freeman et al., 2014; Gardner, 2011; Howard & Miskowski, 2005; Huitt et al., 2015; Jensen & Lawson, 2011; Kamei et al., 2012; Moran & Gardner, 2018; Parmelee et al., 2009; Rissing & Cogan, 2009; Vasani & DeFouw, 2011; Zhan et al., 2015). Collaborative learning with peers is a powerful tool for information transmission (Indriwati et al., 2019; Noteborn et al., 2014; Petrescu et al., 2018; Yasmin & Naseem, 2019), group discussions, and social interactions to influence the learning process (Gardner, 2011; Howard & Miskowski, 2005; Jensen & Lawson, 2011; Minner et al., 2010; Moran & Gardner, 2018; Rissing & Cogan, 2009; Spiro & Knisely, 2008). Students share and apply what they have learned with others in group conversations, allowing them to accomplish CL goals; in contrast, TL is much more cost-effective for educational organizations (Scager et al., 2016; Wang & Degol, 2017; Wu et al., 2015).

Biology learning involves more than just factual knowledge of a subject and pedagogies style, the learner's own student's identities and sociocultural factors influence the outcome of both teaching methods, yet we know very little about it (Chen et al., 2012; Christianson et al., 2007; Economides & Journal, 2008; Khan et al., 2015; Krathwohl, 2002; Lauer et al., 2019; Lee et al., 2017; Shah & Shah, 2012). Although CL has been hailed as a successful approach for improving student learning, retaining science, technology, engineering, and math (STEM) students, and meeting many of the National Science Education Standards, it is not without flaws (Bransford et al., 1999; Calderón & Rachel Slavin, 1998; Jensen & Lawson, 2011; Pratt, 2003; Rutherford & Ahlgren, 1991; Slavin, 1996; Slavin, 2010). For example, previous studies found that students may not always cooperate to promote learning (Barron, 2003; Rummel & Spada, 2005). Furthermore, CL does not necessarily result in equal learning gains and improve class achievement for all students (Almasri et al., 2021; Gnesdilow et al., 2010; Gnesdilow et al., 2013; Teasley et al., 2008). In addition, organizing students into collaborative groups is an essential step and a critical issue that must be addressed (Draper, 2004; Janssen et al., 2009; Kreijns et al., 2003; Le et al., 2017; Schumm et al., 2000) since collaboration in groups may be influenced by various factors such as gender (Almasri et al., 2021; Eaton et al., 2019; Eddy

et al., 2014; Eddy & Brownell, 2016; Makarova et al., 2019; Statista, 2019; Xu & Meier, 2021), gender grouping (Atef, 2019; Barone, 2011; Charles & Bradley, 2002; Gelbgiser & Albert, 2018; Sikora & Pokropek, 2012), undergraduate majors (Arwood, 2004; Knight & Smith, 2010; Sundberg & Dini, 1993; Walters, 2014; Yazici, 2005) social identity (Dou et al., 2019; Fensham, 2004; Mathew, 2014), sociocultural ideologies (Chen et al., 2005; Chen et al., 2012; Economides & Journal, 2008; Gamson, 1994; Smith & MacGregor, 1992; Tellhed et al., 2017) and underlying psychologies associated with gender role specific beliefs, and expectations (Davies & Shackelford, 2008; Gunderson et al., 2011).

Abbiss (2008), Chu and Stress (2010), and Wood and Eagly (2015) emphasize more research on social identities and socio-contextual factors that affect students' achievement (Abbiss, 2008; Chu & Stress, 2010; Wood & Eagly, 2015). Besides adopting a pedagogical method from other cultures, social and cultural variations must be considered to ensure it is relevant to the students' and instructors' sociocultural and religious backgrounds despite schools adapting the same curriculum (Fullan, 2007; Khan et al., 2015; Khan Al-Daami & Wallace, 2007; Kyriacou et al., 1996; Lee et al., 2017; Shah & Shah, 2012). Therefore, we assume that testing the effect of gender grouping in major and nonmajor introductory biology CL and TL classrooms and assessing the efficacy of CL at different cultures are essential steps in exploring cultural dimensions and identifying the appropriate gender categorization. For that purpose, we used social culture theory (SCT), social identity theory (SIT), and gendered socialization theory (GST) (Reinking & Martin, 2018) lenses to develop the research frame for the current study.

Our study is unique as we measured the effect of single-gender (females and males are separated) and mixed-gender (females and males working together) groups with a combination of major and nonmajor introductory biology undergraduate classes by experimenting with CL and TL pedagogies on gender-specific achievements in a unique sociocultural context in Kuwait. We consider the effects of gender segregation in collaborative groups, particularly in student class achievements, to build a strategic education plan that integrates and improves equitable educational goals, recognizes weaknesses and strengths, and detects underlying issues if any arise in the application. The subsequent sections include the theoretical frame, context and the student population of the study, methodology, results, discussion, implications for theory and practice, limitations, and directions for future scholars.

2. Theoretical frame and literature review

Social psychologists posit that gender is a social construct (Andersson et al., 2009; Wang & Degol, 2013). Therefore, gender-specific differences in science education need to be understood by analyzing context-specific sociocultural identities of men and women, underlying psychologies, stereotypes, socially assigned gender roles, and many other unexplored factors (Régner et al., 2014). To understand the reasons and mechanisms behind gender and gender group influence on biology achievements, the gender theories, social identities, and sociocultural theories become appropriate research frames for the current study.

2.1. Gender theory

Gender theorists argue that gender differences are socially constructed as men and women act based on socially accepted gender roles (Andersson et al., 2009). Gender roles are a set of behaviors, attitudes, personality characteristics expected and encouraged based on his or her gender depending on the context-specific sociocultural ideologies (Gunderson et al., 2011). The underlying social psychologies influence the way men and women act in their societies. For example, "boys are raised to conform to the male gender roles and girls are raised to conform to the female gender roles," women supposed to avoid dominance and men should demonstrate masculine behavior, stereotypical societal beliefs that boys are competent in math and girls are better in homemaking (Reinking & Martin, 2018). Often, women are disadvantaged in many societies as they perceive

women as less knowledgeable than men; Gendered socialization theory posits that women socialize differently than men (Andersson et al., 2009). Since early childhood, families, and societies have instilled such differences in socialization practices (Brown et al., 2019; Moschis & Churchill Jr, 1978). Such gender stereotypes influence men's and women's behaviors at later ages, and it is more visible in science education; further, women have not been encouraged to pursue STEM education (Gunderson et al., 2011). Gender inequality due to sociocultural stereotypes in many countries is significant in widening the gender gap in science achievements (Halpern et al., 2007; Hyde & Mertz, 2009). Along the same vein, personality theories interpret that women are naturally introverted and awkward in equal participation in science education classrooms; therefore, such psychologies reflect low achievements (Cheryan et al., 2015). Research carried out in many countries found that such a gender gap in science education is not due to biological factors but is expected to sociocultural and associated psychological negative stereotypes (Marshman et al., 2017). However, researchers agree that psychology in understanding gender gaps in achievements in science education is a gray area (Halpern et al., 2007; Hyde & Mertz, 2009). Gendered socialization theory proponents found that women socialize differently in the US than in other countries, reflecting sociocultural prejudices against men and women, further widening the gender gap in science education and their careers (Daniels & Leaper, 2006; Gonsalves et al., 2016; Smith & Leaper, 2006).

Kuwait, a male-dominated society enriched with conservative culture and time-honored traditions, has a policy of gender segregation in classrooms since lower grades (Al-Saleh & Taleb, 2010; Saleh & Subramaniam, 2019). Hence, interactions between males and females are rare in academic settings. Similar to many contexts, Kuwaiti females have been denied the chance to advance their careers as they are marginalized at work (AlMunajjed, 2006); often, they have been subject to various contextual psychological stereotypes; they are marginalized due to lower aptitude to lead than males. Societal beliefs are that females are less knowledgeable and demeaned when working in groups with male peers (Else-Quest et al., 2013; Gallagher & Kaufman, 2005). Since such underlying societal stereotypical psychologies are a disadvantage for females, males are considered more competent and influential in education and societal endeavors. Therefore, this study would illuminate the underlying realities that influence women's and men's achievements in the biology classroom.

2.2. Social identity theory (SIT) perspectives

Social identity theory relates to a person's sense of belonging to a group (Bond & Hewstone, 1988; Hogg & Williams, 2000; Sellers et al., 1998). Furthermore, one of the most important constructs to consider while studying intergroup relations is social identity (Sohrabi et al., 2012) which refers to how people describe themselves based on their affiliations with specific groups (Hogg & Williams, 2000). SIT emphasizes two dimensions: The psychological dimension describes the cognitive processes underlying social identity, and the motivational dimension posits that people by nature strive to maintain their social identities (Crombie et al., 2003; Turner et al., 1987). It suggests that individuals' response, efficacy, and learning behavior can vary because people define their own identities attached to social groupings and these identifications help safeguard and strengthen their self-identity (Tajfel, 1981; Turner et al., 1987). Social identities attached to gender, gender-specific roles, feminine vs. masculine, specific sociocultural and socio-behavioral aspects such as ethnicity, nationality, religion, race, beliefs, and rituals have been identified as essential research areas (Almasri, 2022b; Eddy et al., 2014; Ong et al., 2011). However, various gender ideologies, culture, and subject-specific social identities unique to specific contexts such as Kuwait that widen the disparities in biology achievements have not yet been investigated (Abbiss, 2008; Chu & Stress, 2010; Keraro et al., 2009; Kim, 2008; Ong et al., 2011). Science education literature contains controversial arguments about stereotypical gender differences. For example, differential outcomes in science education may be due to men and women's inherited personality characteristics; stereotypical threats are not limited to gender as they relate to many other factors such as differences of

personality and abilities, race, ethnicity, and many more unexplored factors (Riegler-Crumb et al., 2012). In contrast, researchers found contrasting results showing no differences in biology achievements between males and females (Strenta et al., 1994).

The personality and social identities may operate as a barrier to collaboration and discussion engagement between men and women students in a group (Johnston & Thomas, 1997). Hobman and colleagues emphasized that students might see themselves as not belonging to their group (113) or prefer to work with students from another group (Bond & Hewstone, 1988). Sellers and colleagues (1998) introduced more group member-targeted items, such as “I have a strong sense of belonging to ingroup persons”, while Evans and Jarvis (1986) concentrated on items that target the group as a whole (e.g. I feel included in this group). Almasri et al. (2021) established that the affective component of social identity is further subdivided into one’s experience of belonging and attitudes toward the ingroup in nonmajor and major biology classes and affects student’s attitudes toward biology (Almasri et al., 2021). Since interaction between students depends on each student’s attitude towards each other and towards the classroom setting, the students are concerned with their personal feelings about being a member of that group, which might impact their class achievement.

There are many unresolved issues due to conflicting findings (Lauer et al., 2013; Lauer et al., 2019); for example, some researchers argue that the gender difference is related to students’ personality factors such as lower learning abilities, anxiety, lower self-confidence (Lauer et al., 2013; Strenta et al., 1994), and students’ negative perceptions may have led to lower achievement (Crombie et al., 2003). Science subject-specific identities: e.g. societal beliefs that biology is a feminine subject and physics is a masculine subject influence men’s and women’s interest in the discipline (Kost-Smith et al., 2010; Meece et al., 2006; Schunk et al., 2008), self-efficacy (Almasri et al., 2021), course-related anxiety due to personality characteristics of the different student population (Pomerantz et al., 2002). Likewise, various researchers found inconsistent and contradictory findings; hence it is imperative to carry out more research in different contexts to surface underlying identity factors that widen the gender gap and lower achievements (Almasri et al., 2021; Fritschner, 2000; Howard, 2006).

Another dimension of the gender gaps in biology learning is discussed specific to identities attached to pedagogical approaches. Science educators often use traditional lecture-based on instructor abilities, policy, and logistical factors, while students perceive such factors based on their social and cultural identity lenses (Crombie et al., 2003; Lane, 2012; Schmader et al., 2004). While in lecture-based classrooms, students’ discussion and participation is low as 2–23% and is dependent on teaching methodologies; this rate is much higher in CL classes (Smith & Seyfang, 2013); students’ class discussion and participation are linked to positive perceptions of the class environment (Crombie et al., 2003). Characteristics of students can have a big impact on how they learn biology. Thus, social identity gives individuals a sense of whom they are based on inner psychological acceptance of their roles; eventually, social identities become the underlying determining factors for their behavior in the classroom and peer discussions (Eddy et al., 2015). While there is a lack of studies on social identities affecting students in introductory biology classes, conflicting and inconclusive research findings led us to examine the underlying root causes of gender differences in achievement.

2.3. Sociocultural theory perspectives

The sociocultural theory posits that human learning is a social process where social interactions play vital roles in developing human cognition and intelligence rooted in a specific society or culture (Eddy et al., 2013; Eddy & Brownell, 2016; Glassman, 2001; Mansour & Al-Shamrani, 2015; Mansour & Education, 2009; Moll, 1992, 2013; Vygotsky, 1997). Culture is a vital factor for shaping students learning preferences, habits, styles, and classroom behaviors because learning is mediated by cultural forms connecting what students learn in the classroom with their sociocultural system and

daily lives (Almasri et al., 2021; Eddy et al., 2013; Ong et al., 2011). Also, cultural factors such as beliefs, values, norms, life, and family-priorities influence learning habits, group/individual achievement, discussion engagement between students, career choices, and learner creativity (Eddy et al., 2013; Mansour & Al-Shamrani, 2015). Students from various cultural backgrounds showed varying group discussion and class participation, satisfaction, motivation, and achievement in CL activities, while learners from different cultural backgrounds may communicate, interact, and work differently (Rapport, 2014). They may encounter different experiences, emotions, and thoughts (Kalolo, 2015; Rapport, 2014). Achievement disparities among minority students in multicultural classrooms are significant as females underperformed their overall grade achievements in undergraduate and graduate-level biology classes (Eddy et al., 2014; Eddy et al., 2015; Eddy & Brownell, 2016); therefore, teaching strategies need to be selected based on cultural variables rather than learning styles (Eddy & Brownell, 2016; Mansour & Al-Shamrani, 2015; Ong et al., 2011). Otherwise, selecting inappropriate teaching strategies reduces scientific creativity among students, lowers learning engagements and achievement. Especially when adopting CL in single-gender and mix-gender groups, the learners' cultural factors should be considered to support each learner and their efficient interaction and goal achievement (Ong et al., 2011).

Science is viewed as a topic where boys have a better chance of achieving academic success and subsequently moving into science-oriented jobs in the United States, the United Kingdom, and much of Northern Europe and Australia (Roberts, 2013; Roberts et al., 2018; Walters, 2014; Walters et al., 2016). Eddy et al. (2014) suggest cultural prejudices in the United States and the United Kingdom portray women needing assistance or specific paths to funnel them into math-oriented education and jobs. Research revealed that, in the western environment, females face stereotype threats, in which they believe they are scrutinized more carefully or are more likely to do poorly in science courses. Likewise, studies found that stereotype threat is one of the primary reasons females perform worse than males in science courses (Galdi et al., 2014; Shapiro & Williams, 2012; Smeding et al., 2013). Thus, gender and context-specific stereotypes and cultural variations become essential variables in measuring the effects of various pedagogies on students' achievements to help females do better (Eddy et al., 2013; Eddy & Brownell, 2016). The culture of the United States differs significantly from that of Kuwait. Several studies indicated that the science curriculum and learning strategies should be relevant to the sociocultural situation in which it is taught (Fullan, 2007; Khan et al., 2015; Khan Al-Daami & Wallace, 2007; Mansour & Al-Shamrani, 2015; Reiss et al., 2010; Tey & Idris, 2012; Van den Akker, 2004). Kuwaiti educators realized the necessity of challenging students' thinking and implementing a new teaching method in Kuwait, such as collaborative learning.

Vygotsky (1997) argued that connecting classroom learning to students' daily lives and cultures. Despite this notion, Kuwait's current scientific biology curriculum was created in and for the United States, where different sociocultural and religious environments exist compared to Kuwait. According to Hamdan Alghamdi and Saud Al-Salouli (2013), several studies have been published in North America, Europe, and Australia, but less is understood about Eastern European reforms in the Middle Eastern nations. As far as we know, there has not been any research done quantifying undergraduate major and nonmajor biology achievement with applying CL and TL methods to predict the size of the gender gaps and the effect of gender group composition as a possible predictor of academic achievement. The uniqueness of the present study lies in the fact that it is the first of its kind and a source of future reference.

2.4. CL vs. TL approaches in biology learning

While science education literature discusses CL and TL pedagogical approaches (Knight & Smith, 2010; Marbach-Ad et al., 2016; Scager et al., 2016), some researchers suggest the need for culturally and contextually appropriate science education pedagogies to achieve higher learning goals (Fensham, 2004; Kalolo, 2015). TL has been argued to be the dominant and cost-effective knowledge

transfer method for generations as it can fit a larger students number lead by expert instructors (Lumpe et al., 2000; Southerland et al., 2007); the demerits are that students become passive listeners who tend to memorize than learning as it provides lesser opportunities to develop critical thinking and interactive social skills (Scager et al., 2016). In contrast, CL enables a higher level of social presence due to team lead active engagement (Marbach-Ad et al., 2016); group social engagement fosters critical thinking while small team collaboration enhances preparing needed skills for the future workforce (Knight & Wood, 2005). Freeman et al. (2011)'s experimental study of CL in introductory biology classes found that students' achievements are higher in team-oriented learning and knowledge retention than TL (Scager et al., 2016). A study in the United States found that females are more likely to collaborate than males in group work, and therefore their achievements are comparatively higher than males (Martinho et al., 2015). Social interaction has been effective in CL classes and found to achieve higher learning outcomes (Scager et al., 2016). Some of the negative criticisms of CL were that it requires a higher level of skills for instructors to implement as it may bring adverse effects if not appropriately done (Bower & Richards, 2006; Kalas et al., 2013). Students from various cultural backgrounds have variable participation, satisfaction, motivation, and achievement as they may communicate, interact, and work differently. During CL activities, they may experience a variety of emotions and thoughts. As a result, when adopting CL in single-gender and mix-gender groups, the learners' cultural factors should be considered to support each learner and their efficient interaction and goal achievement.

Context-specific social identities, stereotype threats, and sociocultural, ideological influences (Johns et al., 2005) are seen in many countries that led us to examine the underlying root causes of gender differences in achievement and participation in single-gender and mixed-gender group environments compared with experimental collaborative learning (CL) and control group using traditional lecture (TL) class environment in Kuwait. Cultural influences encompass a wide range of issues, including cultural and social values, religion, politics, and the prevalence of traditional educational methods, to name a few. For example, according to Al-Fadhli (2008), in Kuwait, cultural and social values are often centered on gender segregation, and Kuwaiti customs place severe restrictions on female students, especially if they are married or have children (Al-Ali, 2010; Al-Fadhli, 2009). As a result, students' backgrounds frequently lack interaction, self-confidence, or opportunities to meet persons of the opposite sex to discuss ideas (Al-Ali, 2010).

2.5. Gender grouping

When implementing CL, the division of students into collaborative groups is a crucial step and an essential issue that must be addressed (Draper, 2004; Janssen et al., 2009; Kreijns et al., 2003; Le et al., 2017; Schumm et al., 2000). Gender grouping is the most straightforward and most practical approach; thus, it has been utilized in various educational contexts the most (Jensen & Lawson, 2011; Sopka et al., 2013; Underwood et al., 2000; Willoughby et al., 2009; Zhan et al., 2015). Asterhan and Eisenmann (2011,) emphasize that students' collaboration styles may be influenced by their gender grouping (Asterhan & Eisenmann, 2011; Asterhan & Schwarz, 2016). When working together in a collaborative classroom, males and females may behave differently due to different communication styles (Zhan et al., 2015). Contradictory findings are that females in single-gender groups outperformed females in mixed-gender groups, but there were no differences between males in single-gender and mixed-gender groups (Curşeu et al., 2018; Myaskovsky et al., 2005). Mixed-gender groups outperformed single-gender ones and displayed a wide range of cognitive processes (Zhan et al., 2015). On the other hand, female students do better than male students, and females converse better in mixed-gender groups than males (Bostock* et al., 2005). However, in a CL classroom, the female-only group fared better (Asterhan & Schwarz, 2016). During group debates, students pay greater attention and use interpersonal relationships (Curşeu et al., 2018). Arguments for gender grouping are still conflicting and inconclusive (Bennett et al., 2007; Bennett et al., 2010; Speck & Mancuso, 2014; Xie & Technology, 2011). Gender categorization is becoming an

increasingly important topic (Zhan et al., 2015), yet it still requires deeper investigation to understand better how students learn best in Kuwait.

Some research found there was no significant difference in group productivity across groups with various gender compositions. For example, Xie and Technology (2011) found that group composition based on gender had no significant influence on CL results in experimental research. There are variations in how females and males learn, talk, and interact (Asterhan & Schwarz, 2016; Kommer, 2010; Rice & Dolgin, 2002) within mixed-gender groups (Hawkins & Power, 2016; Hawkins & Powers, 1999), (Ding et al., 2011; Harskamp et al., 2008). Those who advocate CL argue that mix-gender grouping can foster a diversity of knowledge and experience sharing (Zhan et al., 2015); conversely, students may not be satisfied with CL and claim negative impacts (Asterhan & Eisenmann, 2011). Some other research found that females in mixed-gender groups do worse than females in same-gender groups (Light et al., 2000). Other research has found that high school females learning physics in mixed-gender scored considerably worse on post-tests than males in mixed-gender (Ding et al., 2011; Harskamp et al., 2008). Bennett and colleagues (2010) found that students in single-gender groups were more purposeful than students in mixed-gender groups in science classes (Bennett et al., 2010). Assessment of research in small groups in science classes found that students in single-gender groups were more purposeful than students in mixed-gender groups (Bennett et al., 2007; Bennett et al., 2010), yet the group's gender composition did not affect students' achievement (Bennett et al., 2010; Bennett et al., 2007). Further, most studies that identified gender grouping on student achievements are from various subjects other than biology (Draper, 2004; Guo, 2018; Zhan et al., 2015). Research on biology students is insufficient as it deals only with the minor biology students (Beasley & Fischer, 2012; "Women, Minorities, and Persons with Disabilities in Science and Engineering," 2017) Due to the increased enrolment of females in biology courses in comparison to other STEM subjects in Kuwait (Manee et al., 2013; MOE, 2007; Statista, 2019), we aim to study the impact of gender grouping on the achievement of biology students in major and nonmajor in TL and CL classrooms to identify the most appropriate learning approaches at the undergraduate level biology classes.

2.6. Major VS non-major

Recent calls to action urge sweeping reform in science education, advocating for improved learning for all students in major and nonmajor programs (Bastviken et al., 2011; Frankel et al., 2000; Rutherford & Ahlgren, 1991). Since nonmajor biology students do not have exposure to science subjects in their high schools, nonmajors have unique demands, needs, basic scientific literacy, and connection to everyday life, ranging considerably from majors' requirements (McFarlane & Richeimer, 2015; Walters, 2014). Also, non-science students scored significantly higher than science majors (Wright, 2005). McFarlane and Richeimer (2015) found that nonmajor biology students developed the motivation to take additional science courses in an active inquiry-driven classroom, and they demonstrated equitable competencies compared to majors (McFarlane & Richeimer, 2015). In addition, they concluded that the teaching method motivates and builds confidence and interest in biology (Hebert & Cotner, 2019). However, nonmajors and majors differed in their ability to question, analyze scientific problems, draw conclusions, and showed less confidence, thus showing remarkable differences in learning science majors and nonmajors (Allum et al., 2008; Miller, 2004; Miller et al., 1961). Previous research on student collaborative team learning has focused on learning efficacy, specifically team dynamics and project outcomes in major or nonmajor biology students (Bartlett et al., 1999; Borchgrevink et al., 1999; Lalopa et al., 1999). Nevertheless, research is scarce on how students perceive CL, particularly assessing the influence of gender, gender grouping, and culture on achievements (Makarova et al., 2019; Malika et al., 2019; Martin-Hansen, 2002; Saryed-dine, 2018; Wang & Degol, 2017; Xu & Meier, 2021). These contradictory findings show that major and nonmajor are essential determinants of students' affective competencies, but no study compared

achievements between majors and nonmajor biology classes; hence, inconclusive findings led us to test the differences in majors' achievements nonmajors.

3. Study population

3.1. The context and the student population

Like its Middle Eastern neighbors, Kuwait is a gender-segregated dominant men society, where historically, women receive less attention in formal education (Griffin, 2006). In middle eastern countries, the gender gap between boys and girls is higher than the western countries. For example, a study conducted in the UAE found that the gender gap in the later stages of women's carrier is increasingly higher due to lower academic accomplishments (Atef, 2019; Xu & Meier, 2021). In contrast, a study at Khalifa University found that women performed higher in both mixed-gender and single-gender CL classes compared to men in mixed and single-gender CL classes (Cen et al., 2014). Women recently began entering STEM education; nevertheless, culture, social customs, and Islamic traditions influence men's and women's education and classroom behaviors. Even in selecting majors and careers, women are dependent on their men's family members' discretion (Singh et al., 2008). Many studies found that stereotype threat is one of the major reasons women in science courses perform worse than men (Galdi et al., 2014; Shapiro & Williams, 2012; Smeding et al., 2013). The growing enthusiasm of women to go for biology education can be seen from the increasing student enrollment; however, students' achievements, as evidenced by exam scores and interest in the continuity of science subjects and achievement, are relatively low (Ahmad & Greenhalgh-Spencer, 2017; Al-kaabi, 2016; Al-Khaldi, 2007; Barnett & Francis, 2012). Al-Kandari (2006) posits that such lower students' achievements in Kuwait are because teachers are still using traditional methods that inhibit active inquiry and learning processes. The main challenge facing the education system in Kuwait is to innovate highly effective teaching practices that can bring higher learning achievements overcoming the gender disparities due to sociocultural differences.

3.2. Purpose and the uniqueness of this research

To identify the gaps and consequences of previous research in various other contexts and draw insights from traditional lecture-based (TL) and collaborative constructivist learning (CL) education traditions; we experimented with the effect of gender grouping towards students' achievement using TL versus CL pedagogical approaches in single-gender and mixed-gender for nonmajor and major undergraduate introductory biology course.

This research is unique because our student sample is homogeneous Kuwaiti nationals from male-dominant conservative Islamic traditions. This is the first comprehensive study in Kuwait that measured the effect of TL vs CL, major and nonmajor introductory biology undergraduate classes in single-gender and mixed-gender grouping combinations by adopting a biology curriculum developed in the USA. We expect the findings to have implications for deploying CL and TL pedagogies in different social identities and cultural contexts towards undergraduate biology teaching and learning settings. This experimental comparative assessment will allow researchers to communicate the results with curriculum developers and decision-makers for developing appropriate classroom activities and settings. Remarkably, the findings would help develop a strategic education plan that integrates and improves educational goals in Kuwait, identifying weaknesses, strengths and detecting issues if any arise from this research.

3.3. Research questions

In this study, we implemented traditional learning and collaborative learning in different classes. We investigated how these learning pedagogies and gender segregation of CL groups impact undergraduate biology major and nonmajor students' achievement by using the following research questions that lead to developing the four hypotheses:

- (1) Is there any difference between female's and male's biology achievement implementing CL vs. TL in major and nonmajor biology classes?
- (2) How do single-gender and mix-gender groups affect female's and male's biology achievement implementing CL and TL in major and nonmajor biology classes?

3.4. Hypothesis

HO1: In nonmajor single-gender TL and CL classes, no statistically significant difference exists between men/women students' biology achievement.

HO2: In nonmajor mix-gender TL and CL classes, no statistically significant difference exists between men/women students' biology achievement.

HO3: In major single-gender TL and CL classes, no statistically significant difference exists between men/women students' biology achievement.

HO4: In major mix-gender TL and CL classes, no statistically significant difference exists between major biology men/women students' biology achievement.

4. Methodology

Participants: Female (F) and male (M) students were randomly assigned from program administrative databases into the control TL and experimental CL groups in single-gender and mix-gender classes. The participants were undergraduate students taking biology courses as an elective, considered nonmajor biology, and pre-medical considered majors biology having as a prerequisite course in universities in Kuwait. There were 253 female and 253 male freshmen aged from 18 to 22 years old. Steps were taken to ensure as much group equivalence as possible among the treatment groups (i.e. same exams, classrooms, resources, curriculum, and expected learning outcomes assessment). Researchers assured that no ethical objections to the study were raised. The researchers got approval from the Humanities & Social Sciences Research Ethics Committee (HSSREC) to carry out this study. This approval allows the researcher to carry out the study at the College. The authors received informed written consent from the participants.

The study's individual variables included: (1) Pedagogy method used in class (TL versus CL method) (2) Students' gender (Female & male), (3) Gender group (single-gender, mix-gender), (4) Biology students (major, nonmajor). The dependent variables were (1) students' achievement final grades (2) students' pre-exam and post-exam scores.

Procedures: The researcher utilized the semester structure to implement the innovative teaching methods in a collaborative learning environment and compared it with the control group traditional learning classes. Participants from biology nonmajor & major were randomly divided into CL groups and TL classes, as shown in Table 1. CL and TL methods were applied to major and nonmajor sections. To test our hypotheses, we applied the interventions for the following sections: (1) Single-gender TL classes: male or female in a separate classroom and there was no interaction between students, (2) Single-gender CL classes: male and female in a group of four (4 female) or (4 male) in separate classroom (3) Mix-gender classes TL classes: male and female in sitting in an opposite side from the classrooms and there was no interaction between male and female students as well no groups created; male and female sitting in the opposite side from the classroom, (4) Mix-gender classes CL classes: male and female in a group of four (2 F +2 M) in the same classroom as shown in Table 1. The students had three lecturers per week, each lecture an hour duration for a four-month semester.

4.1. Teaching procedure

Traditional learning Sections: In the traditional learning sections, the instructor used the full hour (3 h/week) lecturing and gave the knowledge directly to the students, guiding every stage of the

Table 1. Major and nonmajor biology students with gender segregations.

		Biology Students				
Gender Group	Teaching Method	Arrangement	Gender	Non-Major (N)	Major (N)	
Single Gender	TL	Individual	Female	30	30	
	CL	Groups of 4	Male	30	30	
Mixed Gender	TL	Females and males have been separated : Females sit on one side of the classroom and males sit on the opposite side of the classroom. there is no interaction between the students	Female	31	31	
			Male	32	32	
	Female		35	32		
	Male		34	30		
	CL	Groups of 4 (2 F & 2 M)	Female	36	34	
			Male	36	33	

process until the end of the lecture. The instructor defines the concept and processes and solves sample questions, where the students do not participate deeply in the learning process, discussions, and questions. Instead, students sit and solve class activities independently and seek information on their own. Students take notes while listening; they learn topics by posing, investigating, memorizing, and performing techniques, with very little interaction with the instructor and their classmates (Christianson et al., 2007; Ilie, 2019; Kamei et al., 2012).

Collaborative Learning Sections: In the CL sections (3 h/week). The instructor used the random number generator function in Microsoft excel to assign four students per group to collaborate and complete the given activity. Students are assigned to stable groups throughout the semester based on the social cohesiveness viewpoint, resulting in a more motivated, pleasant, and successful working environment. As a result, students were allocated to the same group for the whole semester. The instructor considered the learning objectives for the day's session, and the groups had a predetermined plan for the teachings covered in weekly sessions. Consequently, students prepare for the topic and divide lecture content among group members prior to the class; with the instructor's approval, students have immediate access to their own segment from the course materials, and they are also allowed to conduct their own research to learn and prepare their parts. Then during the class, each student introduced and discussed his/her part with their group in order to give a forum for questions and answers. Following each discussion, the instructor handed a worksheet that students work on activities relating to the presented topic, allowing them to debate and answer the worksheet while being supervised by the instructor. These activities might involve a real-life scenario, fill-in-the-blanks, or true/false questions. Furthermore, these activities use around 70% of the class time. The instructor utilized the remaining time to summarize the points, solve the tasks with the students, and make certain that the various solutions to the activity were addressed and explained. In order to actively engage students in the discourse, the instructor facilitated students to evaluate their classmate viewpoints on the giving topic critically, as well to encourage cognitive activity; the teacher offers difficult questions to students to improve their grasp of the targeted topics and the connections between these concepts (Almasri, 2022a; Brophy, 2000; Lee & Brophy, 1996).

Pre-Exam and Post-Exam: Pre-exam is given to measure the outcome variables before the TL control and CL experimental manipulation. Students in each section were given a general biology pre-exam. In addition, a pre-exam was given to each student to collect information on the student's background science knowledge experiences. The post-exam included the same questions they had on the pre-exam and was administered at the end of the semester to compare students' achievements. The instructor had prepared these questions from an exam bank of a published concept inventory (Kalas et al., 2013). Like previous studies (Huitt et al., 2015; Yasmin & Naseem, 2019), the post-exam is done one week before the final to see how much knowledge they have gained during the semester.

Data Analysis: A paired-samples T-test was conducted to test the student groups' significance from the CL or TL population on their pre-exam and post-exam achievements. The Independent Sample T-test was conducted to examine the two groups' achievements on the pre-exam and the post-exam scores for CL compared with TL. Two levels of gender were utilized as independent variables in this study (female, male) pedagogy method (TL, CL), gender combination (mix-gender and single-gender), (major and nonmajor) biology students. ANOVA (one-way) was used to compare student achievement based on pedagogy style; To evaluate significance, an alpha threshold of $p < .05$ was employed (Adibelli & Boyaci, 2018; Myers & Dyer, 2006; Zhan et al., 2015). A linear regression model that includes pre-exam score as a predictor this linear regression model test the intervention if it has a significant impact on student achievement and helps control for observable characteristics correlated with student achievement (Theobald & Freeman, 2014). The significant interaction in the two-way ANOVA effects between student's gender and teaching method used to determine whether there is an interaction effect between three independent variables on a continuous dependent variable. The three-way interaction between gender, teaching method, and gender composition to see which treatment each gender does best.

5. Results

In this study, the dependent variable: achievement compared with the independent variables (a) Gender male (M) / female (F), (b) Teaching methods used TL and CL, (c) Gender group (single-gender, mix-gender), and (d) Biology students (major, nonmajor). Then, applying two-way MANOVA, the dependent variable student's achievement compared with the independent variables (a) Gender (Female (F) / male (M)), (b) Teaching methods used TL and CL. To evaluate significance, an alpha threshold of $p < .05$ was employed (Myers & Dyer, 2006). Tables 2 & 3 presents the pre-test and post-test results as well Tables 4 & 5 presents the total achievement results. Tables 2 & 3 shows the means, standard deviations, and statistical exams of students' group pre-exam and post-exam scores; the max score is 100. TL and CL teaching methods are implemented under the categories (1) Nonmajor single-gender, (2) Nonmajor mix-gender, and (3) Major single-gender (4) Major mix-gender.

5.1. Pre-exam & post-exam achievement

Pre-exam: At the beginning of the semester, students were given a pre-exam, and at the end of the semester, a post-exam was administered. Among nonmajor female and male students, there was a significant difference in the linear regression model applying pre-exam $F(1,260) = 16.209, P < 0.05, R^2 = 0.050$, as well among major sections, there was no significant difference in the linear regression model applying pre-exam as a predictor $F(1,242) = 1.173, P = 0.280, R^2 = 0.005$. Results indicate that pre-exam in nonmajor sections is useful in predicting the total achievement between females and men.

5.2. Overall achievement

The total achievement results presented in Tables 4 & 5, applying an independent t-test to determine achievement differences between teaching methods and the Cohen's d effect size value was calculated. In Tables 4 & 5, we arranged the data according to gender grouping proposed previously to examine men's and female's group achievements for nonmajor (a) and major (b) biology students. The following bar Figures (Figure 1: Single-gender and mixed-gender for Figure 1(a) Nonmajor and Figure 1(b) Major achievements of TL versus CL) visualize the overall achievements compared with single-gender and method.

Table 2. Nonmajor biology data for means, standard deviations, P- values, and Cohen’s d effect size values of students’ Pre-exam and Post-exam dependent variables in groups with different gender compositions (Female (F), Male (M)), TL and CL teaching methods implemented.

Statistical Tests			#N	Mean	SD	Independent Samples t-test P* < .05	Cohen’s d Effect Size	One-way ANOVA P* < .05	Cohen’s d Effect Size	Mean	SD	Independent Samples t-test P* < .05	Cohen’s d Effect Size	One-way ANOVA P* < .05	Cohen’s d Effect Size	Paired-samples t-tests P* < .01
Geder Group	Gender Grouping	Teaching Method	N	Pre-test (μ)	SD	Pre-test(μ) TL VS CL	Effect Size Value TL VS CL	Pre-test (μ) F VS M	Effect Size Value TL VS CL	Post-test (μ)	SD	Post-test(μ) TL VS CL	Effect Size Value TL VS CL	Post-test(μ) F VS M	Effect Size Value TL VS CL	Pre-Test VS Post-Test
Single-Gender (Non Major)	Female (F)	TL	30	55.4	11.15	F P=0.953	F d=0.0231	F-TL VS M-TL P<.001*	F-TL VS M-TL P<.001*	84.1	7.47	F P=0.006*	F d=0.7286	F-TL VS M-TL P<.001*	F-TL VS M-TL d=2.414	F_TL P<.001*
		CL	31	55.7	14.6					88.7	4.89					F_CL P<.001*
	Male (M)	TL	30	37.6	11.16	M P=0.515	M d=0.1691	F-CL VS M-CL P<.001*	F-CL VS M-CL d=1.642	66.4	7.19	M P=0.003*	M d=0.5357	F-CL VS M-CL P<.001*	F-CL VS M-CL d=2.942	M_TL P<.001*
		CL	32	35.9	8.81					70.3	7.37					M_CL P<.001*
Mix-Gender (Non Major)	Female (F) & Male (M) Separate In same class	TL	35 F	53.7	10.14	F P=0.176	F d=0.3293	F-TL VS M-TL P<.001*	F-TL VS M-TL d=1.761	81.4	6.25	F P=0.01*	F d=0.6746	F-TL VS M-TL P<.001*	F-TL VS M-TL d=1.626	F_TL P<.001*
			34 M	37.47	8.19					71.3	6.17					F_CL P<.001*
	Female (F) & Male (M) in the same groups (2M& 2F)	CL (2M & 2F)	36 F	56.6	7.23	M P=0.328	M d=0.2254	F-CL VS M-CL P<.001*	F-CL VS M-CL d=2.425	77.6	4.94	M P<.001*	M d=1.224	F-CL VS M-CL P=0.565	F-CL VS M-CL d=0.1376	M_TL P<.001*
			34M	39.2	7.12					78.3	5.23					M_CL P<.001*

Table 3. Major biology data for means, standard deviations, P- values, and Cohen's d effect size values of students' Pre-exam and Post-exam dependent variable in groups with different gender compositions (Female (F), Male (M)), TL and CL teaching methods implemented.

Statistical Tests			#N	Mean	SD	Independent Samples t-test P* < .05	Cohen's d Effect Size	One-way ANOVA P* < .05	Cohen's d Effect Size	Mean	SD	Independent Samples t-test P* < .05	Cohen's d Effect Size	One-way ANOVA P* < .05	Cohen's d Effect Size	Paired-samples t-tests P* < .01
Geder Group	Gender Grouping	Teaching Method	N	Pre-test (μ)	SD	Pre-test(μ) TL VS CL	Effect Size Value TL VS CL	Pre-test (μ) F VS M	Effect Size Value TL VS CL	Post-test (μ)	SD	Post-test(μ) TL VS CL	Effect Size Value TL VS CL	Post-test (μ) F VS M	Effect Size Value TL VS CL	Pre-Test VS Post-Test
Single-Gender (Major)	Female (F)	TL	30	48.6	8.21	F P=0.527	F d=0.1605	F-TL VS M-TL P=0.036*	F-TL VS M-TL d=0.5462	91.4	4.68	F P=0.281	F d=0.2829	F-TL VS M-TL P=0.003*	F-TL VS M-TL d=0.8183	F_TL P<.001*
		CL	31	47.3	7.99					90.2	3.77				F_CL P<.001*	
	Male (M)	TL	30	44.4	7.13	M P=0.702	M d=0.0968	F-CL VS M-CL P=0.235	F-CL VS M-CL d=0.2869	87.8	4.1	M P=0.247	M d=0.3091	F-CL VS M-CL P<.001*	F-CL VS M-CL d=0.2717	M_TL P<.001*
		CL	32	45.1	7.33					89.1	4.31				M_CL P<.001*	
Mix-Gender (Major)	Female (F) & Male (M)	TL	28 F	49.2	8.51	F P=0.624	F d=0.1235	F-TL VS M-TL P=0.138	F-TL VS M-TL d=0.4065	92.1	4.8	F P=0.491	F d=0.1817	F-TL VS M-TL P=0.004*	F-TL VS M-TL d=0.7794	F_TL P<.001*
		Separate In same class	29 M	45.6	9.19					88.2	5.2				F_CL P<.001*	
	Female (F) & Male (M) in the same groups (2M & 2F)	CL (2M & 2F)	32 F 32M	50.3 44.2	9.29 7.8	M P=0.503	M d=0.1643	F-CL VS M-CL P=0.006	F-CL VS M-CL d=0.7112	91.2 93.7	5.1 5.8	M P<.001*	M d=1.001	F-CL VS M-CL P=0.081	F-CL VS M-CL d=0.4578	M_TL P<.001* M_CL P<.001*

Table 4. Nonmajor biology means, standard deviations, P- values, and Cohen's d effect size values of total course achievement single-gender and mixed-gender for major with different gender compositions (Female (F), Male (M)), TL and CL teaching methods implemented.

Geder Group	Gender Grouping	Teaching Method	N	Achievement (μ)	SD	TL VS CL P -Value Significance	Cohen's d Effect Size Value TL VS CL
Single-Gender (Non Major)	Female	TL	30	79.4	4.16	F P<.001*	F d=1.159
		CL	31	84.6	4.81		
	Male	TL	30	59.4	4.62	M P<.001*	M d=2.805
		CL	32	72.4	4.65		
Mix-Gender (Non Major)	Female and Male have separated:In same class	TL	35 F	78.5	4.23	F P<.001*	F d=1.186
			34	59.8	4.19		
			M				
	Female and Male are placed in groups (2 Females+2 Males)	CL (2M & 2F)	36 F 34M	73.4 79.6	4.37 4.46	M P<.001*	M d=4.576

Table 5. Major biology means, standard deviations, P- values, and Cohen's d effect size values of total course achievement single-gender and mixed-gender for major with different gender compositions (Female (F), Male (M)), TL and CL teaching methods implemented.

Geder Group	Gender Grouping	Teaching Method	N	Achievement (μ)	SD	TL VS CL P -Value Significance	Cohen's d Effect Size Value TL VS CL
Single-Gender (Major)	Female	TL	30	85.1	5.47	F P<.001*	F d=0.8912
		CL	31	89.6	4.59		
	Male	TL	30	75.3	4.73	M P<.001*	M d=1.748
		CL	32	83.1	4.18		
Mix-Gender (Major)	Female and Male have separated:In same class	TL	28 F	84.4	6.15	F P=0.458	F d=0.1837
			29	76.1	6.69		
			M				
	Female and Male are placed in groups (2 Females+2 Males)	CL (2M & 2F)	32 F 32M	83.3 88.6	5.82 5.93	M P<.001*	M d=1.977

5.2.1. Nonmajor single-gender achievement

A significant difference in the achievements appeared in male students' CL compared to TL methods $p < .01$ $d = 2.804$. A significant difference in the achievements appeared in female students implementing CL compared to TL $p < .01$, $d = 1.159$. In nonmajor biology, females outscored male students; both females and males benefit from CL; however, compared to the effect size d value, males benefit more from CL than females; [Table 4](#).

5.2.2. Nonmajor mix-gender achievement

A significant difference in the achievements appeared in male students implementing CL (2F+2M) compared with TL (Mix-gender class with no groups) $P < 0.05$. A significant difference in female students' achievements is implementing CL compared to TL $P < 0.01$. Applying effect size value (d -value), male students benefited more from implementing CL than TL ($M d = 4.575$ versus $F d = 1.185$). Male outscored female students in CL mixed-gender class, and females performed better in TL mix-gender classes than CL; [Table 4](#).

5.2.3. Major single-gender achievement

A significant difference in the achievements appeared in males implementing CL compared with TL $p < .05$ $d = 1.74$. A significant difference in the achievements appeared in female students implementing CL compared with TL $p < .05$, $d = 0.891$. Comparing the effect size value: d value for major biology students, males benefited more from CL than females; females outperformed males in TL and CL; [Table 5](#).

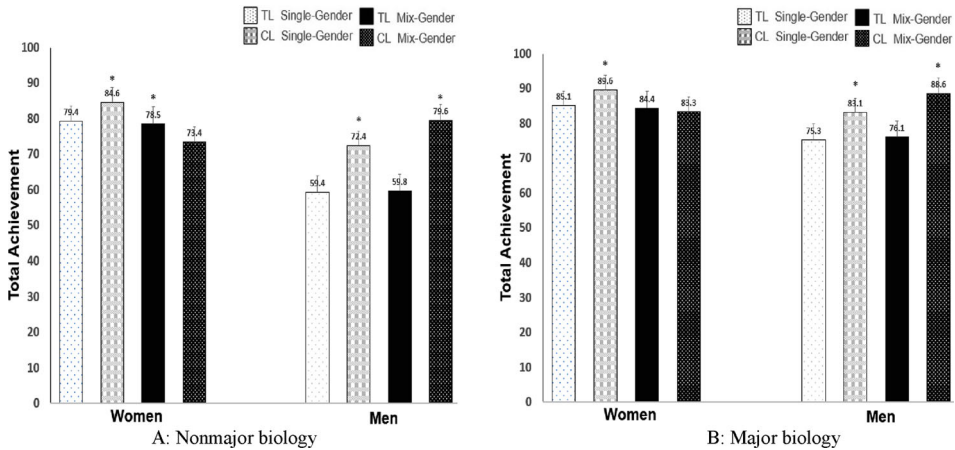


Figure 1. (a) Nonmajor biology (b) Major biology: Single-gender and mixed-gender achievements of TL versus CL. Mean and Standard Deviation of the grades for females and males belonging to four groups as specified in figure 1, comparing the result differences in traditional and collaborative learning methods. Asterisks indicate significant differences ($p < .05$) between TL and CL teaching methods in single and mix-gender classes.

5.2.4. Major mix-gender achievement

A significant difference in the achievements appeared in mix-gender male students' implementing CL (2F+2M) compared to TL (Mix-gender class with no groups $p < .01$, $d = 1.977$). In terms of achievements, there is no significant difference found in females implementing CL compared to TL $p = 0.458$ $d = 0.183$. Applying effect size value (d -value), male students benefited more from implementing CL than TL ($M d = 1.977$ versus $F d = 0.183$). male outscored female students in CL mixed-gender class, and there was no significant difference for a female between TL and CL in major mix-gender classes; Table 5.

5.3. Final exam mark and total achievement versus post-exam achievement

The Pearson correlation was applied to investigate the relationship between students' achievement in the post-exam versus final exam and post-exam versus course overall achievement. Teaching methods impact the post-exam and final exam for nonmajor and major comparably with the student's overall achievement in both single-gender and mix-gender sections. The post-exam average marks were higher than the final exam and the overall achievement since it is considered more general, and students performed higher in the final exam than the total achievement since the students were used to the type of questions.

The two variables, post-exam, and final exam have a strong positive correlation. This positive correlation might happen because the post-exam was done a week before the final exam, so students already covered most of the course syllabus concepts. A moderate/low correlation between the post-exam and the total achievement; The reason for this might be the total achievement includes exams starts from the beginning of the course until the end of the course; where students at the beginning of the course still did not cover most of the syllabus concepts and might do not get used to the learning methodology yet. The correlation results suggest that the students with high achievement in post-exam will have high achievement on their final exam and total achievement. The correlation between post-exam and final exams for students was higher for males than females, especially in the mix-gender classes for nonmajor and major classes. The highest correlation was achieved for males in mix-gender classes, especially CL sections. The lowest in TL single-gender classes; however, the major female classes have their highest correlation between post-exam and final exams in CL single-gender classes, and its lowest in the CL mix-gender classes. This matches

our total achievement results: males benefit the most from CL mix-gender classes, and females benefit the most from CL single-gender classes.

5.4. Gender grouping versus teaching method

For the nonmajor biology students, there was a statistically significant three-way interaction between gender, teaching method, and gender composition $F(1, 254) = 57.523, p < .001, \eta^2 = 0.185, R^2 = 0.791$. Results indicated that nonmajor biology male students performed significantly better in CL classes than TL classes in both mix-gender $p < .001$ effect size Cohen's $d = 4.576$ and single-gender classes $p < .001$ effect size Cohen's $d = 2.805$. male performed significantly better in CL mixed-gender groups (2F+2M), $F(1, 245) = 331.6, p < .001, \eta^2 = 0.56$ compared to male in CL single-gender groups $F(1, 245) = 131.1, p < .001, \eta^2 = 0.34$ with an effect size Cohen's $d = 1.58$; on the other hand, female students performed better in CL (4F) compared to TL single-gender classes $p < .001, d = 1.159$, and worst in CL (2F+2M) compared to TL mix-gender classes $p < .01$ Cohen's $d = 1.186$. female in single-gender performed significantly better in CL (4F) group compare to TL group $F(1, 245) = 18.984, p < .001, \eta^2 = 0.07$ Cohen's $d = 1.159$ and for the mix-gender classes the achievement was higher in TL compared to CL $F(1, 245) = 22.84, p < .001, \eta^2 = 0.083$ Cohen's $d = 1.186$. Results indicate that gender and gender composition interaction depends on the teaching method for nonmajor biology students. Male benefited from CL versus TL in single-gender, and they benefited more from CL versus TL in mixed-gender. Females benefited from CL versus TL in single-gender classes, and their achievement dropped in CL and higher in TL in mixed-gender classes. Teaching methods have a significant effect on achievement; males benefited more and outperformed females in CL, where CL was a disadvantage for females, and as they did not benefit in mix-gender and achieve lower scores compared to TL.

For the major biology students, there was a statistically significant three-way interaction between gender, teaching method, and gender composition $F(1, 236) = 13.139, p < .001, \eta^2 = 0.053, R^2 = 0.448$. Results indicated that major biology male performed significantly better in CL classes compared to TL classes in both mix-gender (M_CL $\mu = 88.6$ SD = 5.93 versus M_TL $\mu = 76.1$ SD = 6.69) $p < .001$ Cohen's d effect size = 1.977 and for the single-gender classes (M_CL $\mu = 83.1$ SD = 4.18 versus M_TL $\mu = 75.3$ SD = 4.73) $p < .001$ Cohen's effect size $d = 1.748$. male performed significantly better in CL mixed-gender groups (2F+2M) $F(1, 236) = 79.441, p < .001, \eta^2 = 0.252$ compared to male in CL single-gender groups $F(1, 236) = 32.199, p < .001, \eta^2 = 0.120$; the Cohen's effect size $d = 1.977$. On the other hand, female performed better in CL (4F) classes compared to TL in single-gender classes (F_CL $\mu = 89.6$ SD = 4.59 versus F_TL $\mu = 85.1$ SD = 5.47) $p < .001, d = 0.8912$, and no significant difference between CL (2F+2M) in mix-gender classes compared to TL (F_CL $\mu = 83.3$ SD = 5.82 versus F_TL $\mu = 84.4$ SD = 6.15) $p > .01$ Cohen's $d = 0.1837$. female in single-gender performed better in CL (4F) group compared to TL class $F(1, 236) = 10.302, p < .001, \eta^2 = 0.042$ Cohen's $d = 0.8912$ and there was no significant variation in achievement between the CL and TL courses in the mixed-gender classrooms $F(1, 236) = 0.558, p > .001, \eta^2 = 0.002$ Cohen's $d = 0.1837$. The interaction of gender and gender composition in major biology classes depends on the pedagogy method. Male benefited from CL versus TL in single-gender, and the benefits were more from CL versus TL in mix-gender. Females performed better in CL single classes than TL, and there was no difference between CL and TL in mixed-gender classes.

Major-biology males benefited more from CL than females. This result indicates that the significant differences in achievement scores between students taught with CL and TL teaching methods linked and depended on student's gender in nonmajor single and mix-gender as well as the major single-gender and mix-gender male and female. So the combination of the gender and teaching methods used in classes does affect students' achievement in Biology. Looking into the impact the teaching methods have had on students' achievement for the male and female separately, the teaching method toward student achievement changes according to gender. Even though

there was a significant difference in applying the CL method in major biology, the difference appeared to be higher on nonmajor biology students.

In summary, both males and females benefited from CL in single-gender classes. Whereas in mixed-gender classes, for nonmajor students, there was a significant gender difference in achievements between males and females as male students outperformed in CL over females. Where are females in the mixed-gender CL-class at a disadvantage in terms of achievements; on the other hand, for the major students, males benefit more from CL in the mix-gender, and there is no significant difference in CL sections for female's classes in single-gender and mix-gender. Thus, the intervention impacts the student's achievement in gender different composition classes and teaching methods treatment, leading to enhanced student achievement in major and nonmajor sections.

6. Discussion

This is the first thorough research that we are aware of that integrated with the findings of mixed-method research comparing the gender-specific achievements of two teaching pedagogies (TL and CL) in single-gender and mixed-gender (2F+2M) introductory Biology classes in a university in Kuwait. In a semester-long introductory biology classes [Tables 4 & 5](#), we found interesting results that females in biology major and nonmajor performed higher in all their exams in both TL and CL classes in a single-gender learning environment. In contrast, males performed higher in mixed-gender (2F+2M) CL-class exams. In our experimental study, the independent t-test helped us determine gender differences between teaching methods as we found a significant gender difference in achievements. Our findings confirm that males' achievements improved more in implementing CL & TL mixed-gender (2F+2M), and there were significant changes between the female sections. Both achievements shown between females and males demonstrated a significant difference at a $p < .05$. A factorial ANOVA was used to examine students' gender and the interaction impact of their gender on achievement. Though the TL and CL pedagogies have affected students' achievements, that effect differed between male and female students. Based on the findings, we conclude that males benefited more in CL with $\mu = 72.4$ compared to TL with $\mu = 59.4$, thus the difference of achievements between two teaching pedagogies with 13 points improvement. Though females had a small effect size in CL (2F+2M) compared to TL, they generally were inspired by the opportunity to learn day-to-day life-related biology concepts irrespective of a biology major or nonmajor. This result is somewhat contradictory to the previous research findings of Knight and Smith (2010) and Knight and Smith (2010); those students in nonmajor come with lesser enthusiasm and lower knowledge levels; therefore, universities offer different introductory biology courses for majors and nonmajors. In Kuwait's context, females performed equally higher in our study when we used the same curriculum for majors and nonmajors. Such gender differences in achievement shown in Kuwait science classrooms conform to the phenomenon expressed in sociocultural ideologies and gender role theories (Andersson et al., 2009) and personality theory that posits females are naturally introverted and feel awkward, hence they hesitant to participate equally in mixed-gender groups (Cheryan et al., 2015). Further, we argue that gender-stereotypical threats (Cavallo et al., 2004) may have reflected in females' lower achievements. On the contrary, creating a conducive learning environment integrated with appropriate teaching pedagogies can bring differential results in conservative, traditional societies, thus leading our findings to a new theoretical argument.

We conclude that CL brings higher learning outcomes for males in (2F+2M) groups in introductory biology, and mixed-gender grouping was not beneficial for female achievement. While males were more inclined toward CL in major biology classes, females were disadvantaged by having mixed-gender CL classes. We found somewhat contradictory results compared to Martinho et al. (2015)'s study that females in the USA performed higher in CL (2F+2M). The findings support our argument that developing context and gender-specific teaching approaches and classroom practices specific to the context would bring higher learning achievements. Gender grouping is an essential determining factor of achievements. In the subsequent sections, we include our discussion

points in specific topical areas as achievements in major and nonmajor, gender identity and achievements, and the influence of contextual factors on achievements.

6.1. Achievement based on gender theory, social identity, teaching approach in science major and nonmajor

Compared to previous research on students' achievements by gender and teaching methods in various contexts, we found inconsistencies and some similarities. Our findings are somewhat contradictory with Knight and Smith (2010) that students in nonmajor are not so motivated to learn biology; however, our results are to some extent consistent with Zhan et al. (2015) that the achievements of males were significantly high in mixed-gender (2F+2M) groups than single-gender groups. Our findings confirmed that males are objectively motivated to perform biology majors and nonmajors in CL mixed-gender grouping environment as they believe they must specialize in science. These findings are consistent with the gender socialization theory perspectives (Reinking & Martin, 2018), reflecting socially assigned roles and mindsets that men are smarter and more knowledgeable than women could have influenced superior performance to prove men's masculinity power when women are present in their groups. However, future research is needed to reconfirm or reject the gender stereotypes and gender role-specific power perspectives associated with gender disparities in biology achievements.

Regarding the test of males' and females' achievements against TL and CL pedagogies, we found that females performed higher in all their exams in both TL and CL in single-gender biology classes. In contrast, males performed significantly higher in CL in mixed-gender major and nonmajor classes while females achieved $\mu = 79.4$ compared to male's achievement of $\mu = 59.4$ in TL; and females achieved $\mu = 84.6$ in CL single-gender class compared to male's, $\mu = 72.4$ in CL. We conclude that males performed better in mix-gender biology CL classes (both major and nonmajor) as they were motivated to show their masculine power and ego in front of a female, as they were socially treated as subservient to males. Our observation was that males took the class more seriously and worked hard when females were in groups. Thus, societal and ego feelings act as motivators for males, while for females, mixed-gender grouping (2F+2M) hinders their ability to perform equally. This conclusion reaffirmed that females showed significantly higher achievement in single-gender TL versus CL, irrespective of major or nonmajor. These gender-segregated societal beliefs influenced females inhibiting their true potential in the mixed-gender learning environment. Claro and Hebert found that nonmajors females outperformed in exams compared to biology majors (Claro et al., 2012; Hebert & Cotner, 2019). Irrespective of socially assigned gender role behavior, culture-specific prejudices, and stereotypes (Daniels & Leaper, 2006; Leaper, 2006), there was no significant difference between the TL & CL in the mixed-gender major female as they did not disadvantage from the CL environment. A possible reason might be that most of these females in the major are employed in hospitals and trained to work in a normal mixed-gender work environment. These findings would be useful for practitioners to provide learning opportunities for working females to improve biology achievements.

Implementing CL in biology classes positively impacts students' attitudes towards biology (Almasri, 2022a; Fareo, 2019); positive and negative attitudes influence achievement, motivation, and student interest (Almasri et al., 2021; Miller et al., 1961). A significant relationship was discovered between students' perceptions and attitudes regarding biology and the classroom environment, such as the teaching method and group discussions (Telli et al., 2005). Furthermore, CL activities improve students' motivation towards biology (Almasri et al., 2021; Indriwati et al., 2019). Motivation has been proven to have a well-established relationship with students' attitudes about biology and a significant relationship with students' achievement and interest. (KİŞOĞLU, 2018; Madden, 2011; Walters, 2014). According to Johnson et al. (2000), learning activities, such as debate, impact students' motivation and achievement. Furthermore, Driver et al. (2000) demonstrated how using scientific argumentation principles facilitate the creation of more suitable scientific conceptions, resulting

in a greater understanding of the subject matter (Driver et al., 2000; Johnson et al., 2000; Johnson et al., 2002).

Moreover, CL activities and group involvement discussions enhance self-efficiency and self-determination (Almasri et al., 2021; Darner, 2014) and it found that self-efficacy was the best predictor of course performance (Partin et al., 2011). In general, self-efficacy is found to correlate highly with achievement (Creer & Wigal, 1993). One potential explanation for this result is that when students regard themselves as inexperienced in a scientific subject, they tend to underestimate their talents, further undermining their confidence. In addition, self-determination correlates with factors like college GPA (Glynn et al., 2009). Similarly, in 2015, self-determination was significant with achievement (Yeoh & Ierardi, 2015). This matters in biology education because the stronger is the self-determination, the better chances that students will be involved in biology classes leading to higher achievement. Working in groups and engaging in thinking activities helps students comprehend that science is a social activity focused on debate and reduced their perception of biology as a complex or tedious topic, and reduce anxiety towards the topics and class assessment (Almasri, 2022a, 2022b; Almasri et al., 2021; Hewapathirana & Almasri, 2022; Seyranian et al., 2018). These findings imply that CL groups assist students in better comprehending the topic. After the semester, these students demonstrated a greater understanding of the relationship between biology class accomplishment performance. They also reported a greater sense of control over their schooling.

Furthermore, those who favor CL methods found positive outcomes as they assumed that CL creates opportunities for students to carry out interactions that enhance cognitive and social relations as motivators for higher achievements (Inglehart et al., 1994; Knight & Smith, 2010; Zhan et al., 2015). These findings question Régner et al.'s (2014) conclusions that in recent times, women are not barred from going in for science education as they demonstrate equal capabilities of achieving equally higher achievements compared to men students, also affirm that other variables, such as the learning climate or the teaching methods, may have influenced women's motivations to perform equally.

Students' discussion increases their awareness of knowledge gaps, alternative approaches to problem-solving, and the numerous roles of the targeted ideas are to discuss and compare the answers of various students with one another and with the canonical solution. As a result, misconceptions are cleared up, and students internalize the necessary solutions (Brophy, 2000; Lee & Brophy, 1996). Furthermore, working in groups and engaging in thinking activities helps students comprehend that science is a social activity focused on debate and reduces their perception of biology as a complex topic, besides encouraging positive attitudes, interest, and motivation towards biology topics that leads to higher achievements.

6.2. Impact of gender identity on achievements versus teaching methods

Kuwait's educational system is segregated based on gender from 1–12 grade. This gender division goes back to the sociocultural background of the country. Though historically, a small number of females entered into higher education, the recent trend is that females are increasingly enrolled in previously shunned STEM fields. The emerging trend in Kuwait generated enthusiasm within females in higher education to outperform males in general. Inglehart et al. (1994) found that while females tended to focus more on the interpersonal aspects of competition, males tended to concentrate on achievement-related elements of competition. Our findings were that females preferred a single-gender learning environment, generating enthusiasm and opportunity to enhance their self-confidence. Those who favor CL methods found positive outcomes as they assumed that CL creates opportunities for students to carry out interactions that enhance cognitive and social relations as motivators for higher achievements

However, the mixed-gender environment blocked female's psychological drive to demonstrate their true abilities to perform in terms of achievements irrespective of the teaching methods. In contrast, males favored a mixed-gender class environment as they get an opportunity to demonstrate

their ego and masculine supremacy in front of females; thus, the mixed-gender grouping has been a self-motivation factor that enhanced achievements for males. These contradictory gender-specific findings generate paradoxes of teaching science in culturally gender-segregated societies that need innovative pedagogical approaches. Therefore, we argue that the severity of socially constructed stereotypical gender role influence can be minimized if instructors create a conducive learning environment for women to develop themselves as equal contributors, even in highly gender-segregated societies such as Kuwait.

6.3. Context-specific influences on learning biology

Despite changes in many aspects of the educational landscape and science curricula, Fensham (2004) and Ogawa (1986) emphasize seeing science education as a culture within a cultural context because students' frames of reference are influenced by those in and out cultural beliefs and ideological factors. For example, we believe that social identities such as masculine and feminine may have influenced males' and females' achievements. Therefore, educators believe there is a need to develop a context-specific science curriculum considering the effect of underlying social-psychological beliefs of various social identities and practices related to students' daily lives (Ogawa, 1986).

In Kuwait's specific situation, due to the new constitutional changes, freedom, and equal treatment for all genders, females began entering into science majors. With the women's freedom and establishment of university-level science programs, females' enrollment in undergraduate science education has steadily risen during the last few years. With the recent changes in the socio-political and educational environment and global economic systems, the need for developing a competent STEM workforce is felt more than ever before. As a result, many educational institutions began experimenting with innovative science pedagogies to attract males and females. However, low enrollment and retention of female students have been a grave concern for many universities to improve student recognition and achievement (Wang & Degol, 2017). In this context, localization of science curriculum and teaching practices would help bridge specific knowledge and incorporate indigenous science knowledge into modern science learning to generate higher motivation (Kalolo, 2015). Such understanding prepares teachers to innovate new context-specific pedagogical strategies and curriculum to increase student learning and achievements while encouraging students to apply scientific knowledge in their daily lives (Desimone & Garet, 2015).

This study's overall contributions are significant as it found the factors that enhance or hinder male and female's achievements in the biology major and nonmajor. It also explains the underlying ideological and socio-psychological gender identity factors and their impact on students learning towards CL versus TL approaches. The findings will be useful for academics to select the best possible methods based on gender, social identities, and the context of learning and promoting heuristic discovery-oriented learning on the part of students, and testing the impact of pedagogical methods commonly used in Kuwait. This study is unique as it integrated multiple methodologies to bring up a comprehensive understanding of the phenomenon to lay the foundation for rethinking new ways of teaching science subjects to minimize the adverse effects of socially constructed gender role stereotypes, identities, and context-specific challenges. We conclude that it is time for instructors to recreate more effective science teaching practices, methodologies, and learning environments to encourage men and women in science education-specific to sociocultural contexts.

7. Limitations, future research, and implications

7.1. Limitations

When comparing the findings with previous research, this study can have some context-specific variations. We did not test relationships of the effects of culture, society, and religion-specific values, and this can be a limitation as cultural values, and religious ideologies are deeply rooted in Kuwait society

and education. However, in Kuwait, instructors use pedagogies that were developed in the western context. The learning community in the classroom in Kuwait was identified as a challenge for the instructor to generate a space for each student where no student should feel left behind. This study was conducted in a unique environment where gender differences play a distinctive role in addition to prevalent attitudes towards engaging in-class discussion. Due to these differences, generalizability is limited to similar contexts and deserves future research in this respect.

7.2. Future research

Since this is the first experimental study in introductory biology courses in Kuwait with unique educational and sociocultural practices, there is a potential new stream of research. We hope our findings will generate new discourse and future research to experiment with innovative pedagogies in various sociocultural contexts. It is essential to research how the context, culture-specific roles, and underlying ideologies influence science learning outcomes. The current study's findings show that females' achievement is higher than males in single-gender classes. In contrast, males' achievements are higher in the mixed-gender classes, leading to another stream of research exploring potential solutions to answer the question of what teaching styles, activities, and grouping would bring equal or higher achievement for both men and women in conservative cultures such as Kuwait. Exploring the paradox of single-gender versus mixed-gender and teaching styles at the undergraduate level may generate new knowledge beneficial for future practitioners. The underlying psychology behind socially assigned gender roles and social identities of men and women related to achievements and attitudes in higher education in general and especially for the STEM classes can be another research area. Only grouping can be tested and compared with mixed-gender grouping to assess how gender-specific attitudes influence men and women. Similar experiments can be done in various class settings in similar or different subjects and contexts to compare the findings. A relationship between instructor-specific differences such as gender, teaching style, and student learning achievements is helpful to research. For future policy decisions, it is worthwhile to understand how the secondary and lower secondary level gender-segregated educational practices influence and reflect university-level education. Comparative experimental studies of learning outcomes in the Middle Eastern region where various religious ideologies exist can be another aspect of future research.

7.3. Implications

The findings will have implications for policy, theory, practice, and future research. The findings that irrespective of the teaching methods, gender-specific achievements are interesting because females performed higher in both TL and CL in single-gender environments in biology majors and nonmajors, thus reflecting the influence of gender stereotypical ideologies. In contrast, males responded differently to each teaching method as they performed better in mixed-gender CL environments in biology majors. Male performed better when they were in groups of 2F+2M in biology majors. These findings can have implications on initiating a new discourse for context, gender, social identity, and science major-specific future theory development and context-specific policy making. For males, CL, a mixed-gender group environment, benefited and stimulated self-motivation enhancing their active engagement compared to the TL environment. This pioneering experimental study in Kuwait can lead to future research that may surface underlying factors that affect gender-specific learning behaviors specific to the context, perhaps experimenting with innovative teaching methods and creating a learning climate that better fits specific sociocultural environments. STEM education in Kuwait is growing as women enter nontraditional education and vocations. Thus, policy makers need to provide gender-neutral policies to accommodate both men and women in science-specific careers and workforce development. For instructors, our findings suggest that selecting appropriate teaching pedagogies and learning environments for science teaching needs

to be reconsidered depending on students' gender, socio-ideological, and contextual factors (Beier et al., 2016). The results can be a call to improve STEM education in different contexts by developing innovative science learning approaches to cater to a new genre of students who bring different expectations, behaviors, and characteristics. The result perhaps leads to a new learning theory specific to STEM education as it suggests considering various dependent and independent variables such as gender, attitudes, learning climate, prevalent sociocultural practices, egos, mindsets, multiple identities in determining specific teaching approaches that can bring higher learning achievements for particular students in various contexts. Especially, our experiment of active learning activities in collaborative groups generated a new understanding of how to encourage men and women to utilize their learning potential. These findings guide instructors to rethink innovative teaching strategies such as new projects and activities that inspire students in different sociocultural contexts because the contextual elements can support or hinder factors.

8. Conclusion

We have demonstrated a comprehensive understanding of critical variables such as single-gender and mixed-gender, science major and nonmajor, gender-specific achievements towards TL versus CL pedagogies in teaching introductory biology courses in Kuwait. Comparing the findings of an experimental study, pre-exam and post-exam, and overall achievements to gain a holistic understanding of what best teaching approaches would bring higher outcomes. It shows that gender has been an important factor when developing teaching approaches. Nevertheless, there is a need for future research to surface underlying gender and context-specific factors that affect science education. The findings provide valuable guidelines for our quest to understand which pedagogical methods result in higher learning outcomes in science education in single-gender and mixed-gender learning environments. Gender identity and associated roles, social identities, context, and associated societal beliefs and individual egos have been identified as the most vital determining variables that guide instructors in developing innovative teaching approach specific to science teaching in Kuwait or similar contexts. Our research findings guide practitioners to determine which innovative teaching approaches and learning environments would help improve males' and females' achievement towards science subjects. The findings are useful for universities and instructors who invest money and time to test the effects of various pedagogies on student achievements, engagement, motivation, and boost learning achievements that eventually prepare the workforce for future science career opportunities that benefit nations economically socially sustainability.

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