Exploring Capital and Privilege in Computing and Engineering Education through Gamification

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***Abstract*—This full paper presents an innovative board game, "Game of Life: Educational Pathways" developed as an engaging pedagogical tool to explore the theories of social reproduction, opportunity structures, and educational attainment through the concept of capital. Drawing inspiration from the traditional "Game of Life," this adaptation provides a participatory learning experience that delves into the complexities of educational pathways, privilege, socioeconomic factors like capital, and their cumulative impact on life outcomes. The game challenges players to navigate through a series of life stages and decision points related to education, where their choices and the inherent randomness of dice rolls simulate the unpredictable nature of life's opportunities. By simulating the journey through different educational and life outcomes based on various forms of capital — Talent, Wealth, Goodwill, Legacy — the game offers a hands-on approach to understanding the complexities of opportunity and achievement in computing and engineering education. This interactive tool not only aids in grasping complex educational theories but also highlights the importance of personal effort, policy, and practice in overcoming barriers for educational participation. Ideal for educational settings, "Game of Life: Educational Pathways" prepares future computing and engineering professionals to navigate and contribute to a more equitable field.**

***Index Terms*—Gamification, educational attainment, capital, opportunity structures, intersectionality**

I. Introduction

The computing and engineering fields stand as pillars of innovation and technological advancement, yet they continue to grapple with significant disparities in participation and diversity, especially in the US and Western countries [1]. Despite various initiatives aimed at increasing enrollment [2], the challenge extends beyond mere numbers to the deeper issues of equitable graduation rates and the crucial sense of belonging among students from diverse backgrounds [3]. This gap in belonging and achievement is not merely a statistic; it reflects a broader systemic issue that influences the potential for diversity to enrich and advance the field. As computing and engineering careers become increasingly globalized and continue to drive economic growth [4], the ability to navigate and contribute positively within diverse teams is not just beneficial, but essential. The urgency to address these educational and social disparities is amplified by the rapidly evolving demands of a global workforce [5], where the capacity to understand and adapt to diverse perspectives directly impacts innovation and problem-solving.

There is a growing recognition that experiential learning tools, such as educational games, can offer a more engaging and impactful method for exploring complex social issues [6]. Games provide a safe, controlled environment where students can experience the consequences of social, educational, and economic decisions firsthand, making abstract concepts tangible and relatable [7]. Drawing inspiration from historical games like Monopoly and Game of Life, "Game of Life: Educational Pathways" emerged as a tool tailored for computing and engineering students to learn about the principles of privilege, intersectionality, and educational opportunity structures [8]. This game has been meticulously designed to balance the elements of randomness and player choice, ensuring an engaging and fair gameplay experience that reflects real-world dynamics. The game delves into the nuances of educational attainment, opportunity structures, and the impact of various forms of capital — Talent, Wealth, Goodwill, Legacy — on life trajectories in the computing and engineering fields [9]. The game provides an engaging modality for students to explore and understand the complexities of social equity and personal identity [10]. By simulating life paths where players experience the impact of decisions and circumstances, the game facilitates a deep understanding of how systemic barriers operate and how personal and collective actions can impact these challenges. Engaging with this game not only educates students about external social dynamics but also fosters personal introspection and reflection on the concept of identity. It equips students with the skills necessary to influence the culture of their departments and future workplaces positively [11]. By integrating these lessons into their professional lives, students can contribute to creating more inclusive environments that value and utilize diverse perspectives, ultimately leading to more innovative and effective solutions in computing and engineering.

II. Background

The educational journey of students is profoundly shaped not only by the immediate learning environment and pedagogical approaches within the classroom but also by broader societal structures that influence their identity development. This complex interaction between individual identity and systemic forces plays a critical role in determining both the access to

and the quality of educational experiences. This section of the paper aims to highlight the interconnections between various social and cultural factors and the educational pathways of individuals, thereby shedding light on the nuanced challenges students face within educational institutions, particularly in computing and engineering fields in the US and Western countries.

Previous research has highlighted a number of structural, social, and psychological explanations for why students engage with computing and engineering education, including students' social support [12] and perceptions of role models [13], self-efficacy [14], and beliefs and values [15]. For example, research shows that when students experience a sense of belonging, they are more likely to persist through academic challenges and earn their degrees [16]. Accordingly, four key factors were found to contribute to a sense of belonging for most students: interpersonal relationships, perceived competence, personal interest, and science identity.

Interpersonal relationships refer to the way one connects with the field through relationships with peers and faculty as well as the frequency of interactions and intensity of those relationships [17]. Perceived competence relates to the concept of self-efficacy, referring to an individual's belief in their ability to successfully perform a specific task or achieve a particular goal [18]. Self-efficacy affects students' motivation and learning, and in turn, the educational choices that they make [19]. Personal interest are an individual's liking for something or someone. In the context of education, students tend to develop interests in subjects for which they possess strong self-efficacy and positive outcome expectations [20]. Science identity is defined as one's personal connection to their field, meaning science is a part of their sense of self [21]. The relationship between these variables is therefore important for understanding the social and personal factors underlying participation in computing and engineering subjects.

This student engagement, or lack thereof, is further mediated by race and ethnicity [22]. Research shows that race and racism play central roles in structuring inequality and relationships of power and subordination in education [23]. Especially in the United States, research in this area finds that computing and engineering education complies with several taken-for-granted routines that privilege White interests and go unremarked in the political mainstream. Another parallel issue of concern is that only 16% of teachers consider themselves very well prepared to incorporate students' cultural backgrounds into computer science instruction [24], despite 17% of students graduating with a bachelor's degree in computer science in the US identifying as female, 8% as Black, and 9% as Hispanic [25]. This directly translates to the low representation of these identities in the field of computer science as only 24.7% of those employed in computer and mathematical occupations were female, 8.6% Black or African American, and 6.8% were Hispanic or Latino [26].

Additional barriers to student engagement that contribute to the lack of diversity in computing and engineering education have been identified as stereotype threat, impostor syndrome, and misconceptions about the field [27]. Teachers' assumptions about their students and students' assumptions about themselves thus play a big part in why over the years there has been a continuous underrepresentation of certain groups in the field of computing [28].

From the perspective of faculty, another issue that has become a barrier is the teaching philosophy of a teacher with regard to the issue of learning competencies and meritocracy. Where above-average students who find the assignment tasks trivial may become bored and lose interest in the course, average students who are given too high a bar often become frustrated and disengaged. Catering to both ends of the students' spectrum, therefore, requires different formative learning pathways with varying numbers of steps and extent of guidance but leading to the same final outcomes. This extra preparatory work is often perceived as extra work by teachers [29]. In addition, with the way computing and engineering education is positioned, technology impacts teaching practices more directly due to the content nature than other disciplines. Some work has been done in assessing the effectiveness of the first Computer Programming course offered to computer science and computer engineering majors but very little in conjunction with the impact of equity and inclusivity [27].

Grasping the complexities of how identity shapes educational experiences is challenging. The subtleties of individual and collective identities, coupled with systemic inequities, make it difficult to address these issues comprehensively within standard curricula. There often exists a significant gap in educational programs, where insufficient time is allocated to critically analyze and understand these fundamental concepts independently. Educating students about the influence of identity and societal structures on educational paths is crucial. Understanding these dynamics empowers students to navigate their educational environments more effectively and fosters a more inclusive, empathetic academic community. For educators and institutions, this knowledge is vital in developing strategies that mitigate biases and structural inequalities, thereby enhancing educational equity. In computing and engineering fields, where innovation depends on diverse perspectives, fostering an inclusive environment is not only a matter of social justice but also a prerequisite for true scientific and technological advancement. This understanding could ultimately influence the culture of entire departments, enriching the educational landscape and preparing students to thrive in diverse professional settings.

A. How games have previously been used to represent life and teach about life

Games have long been recognized as powerful tools for teaching complex theories and concepts through interactive and engaging means [30] [31]. Different types of games, including board games like Monopoly, The Game of Life, and even traditional games like Snakes and Ladders, Chess, Go, and Backgammon, have been utilized to convey lessons about economics, life decisions, and moral values [32]. Games provide a dynamic environment where players can experiment

with different strategies and witness the immediate consequences of their decisions. This active participation enhances learning and retention. Many games are designed to reflect real-world systems and theories, allowing players to develop an understanding of complex concepts through simulation and role-playing [33]. For example, economic simulations in games can help students grasp the complexities of markets and economic strategies. Games naturally motivate players to achieve goals within the game, which translates into an engaging learning experience that can make complex theories more accessible and enjoyable to learn. Games often require players to reflect on their decisions and strategies, fostering skills like critical thinking and strategic planning. These skills are essential for understanding and applying theoretical knowledge in practical scenarios. In short, games like Monopoly, The Game of Life, and Snakes and Ladders not only provide entertainment but also serve as effective educational tools. They bring theoretical concepts to life, allowing students to explore and understand these concepts in a contextual and memorable way. Through the strategic use of games, educators can enhance learning outcomes and provide students with a deeper understanding of theories across various disciplines.

III. Theoretical Frameworks

Educational attainment refers to the varying levels of educational success by individuals. Researchers study an interplay of variables including individual characteristics, family resources, and broader social and economic factors as it relates to educational attainment [34]. Research in this domain is often conducted to analyze patterns of educational success and failure and to identify ways to improve educational outcomes for underrepresented groups. For this section, the most fundamental theories in the domain of educational attainment are listed, namely opportunity structures theory, intersectionality theory, capital theory, and social reproduction theory.

A. Opportunity structures theory

Opportunity structures theory explores how differences in the availability and quality of educational and professional opportunities impact individuals' career trajectories and life outcomes [35]. In the context of computing and engineering education, opportunity structures are often biased or discriminatory, disadvantaging underrepresented populations [36]. For students from more privileged backgrounds, these opportunity structures are more natural to navigate, and the structures reflect sociocultural norms in which they feel valued and comfortable [37]. A recent study finds that traditionally underserved students do not experience equivalent opportunity structures compared with their well-represented peers [38]. Modifying traditional opportunity structures to serve students better may provide the needed changes to engage and retain traditionally underserved populations.

B. Intersectionality Theory

Intersectionality theory provides a framework for understanding how various social identities, such as race, gender, class, and others, intersect and interact to shape individuals' experiences and opportunities [39]. In this theory, complex identity is the culmination of an individual's intersecting identities that cannot be understood in isolation. While gender is often recognized as the primary identity in higher education research, other identity dimensions such as race, ethnicity, and sexuality shape an individual's experience in education [40]. This intersectionality of identities influences how individuals navigate educational spaces and systems [41]. For example, a person who belongs to a marginalized racial group with a different gender identity and socioeconomic status faces multiple forms of oppression [39]. Having these intersecting identities causes unique challenges that differ from those experienced by individuals with a single-axis identity, as policies, practices, and institutional norms perpetuate inequalities based on intersecting identities [42].

C. Capital theory

Capital theory posits that the strength and volume of an individual's capital determines their class position, thereby influencing their ability to generate social advantage [43]. Broadly put, capital can be understood as a type of resource that is valuable and exchangeable. Moving beyond its economic understanding, Bourdieu identified social, cultural, and symbolic forms of capital which influence an individual's access to education, and shape their educational experience. Capital theory provides a lens through which to understand how social and cultural factors contribute to the unequal distribution of educational opportunities and outcomes in society. Individuals with more capital are often better positioned to engage with and succeed in the educational system, while those with less face additional challenges and barriers. Economic capital refers to an individual's wealth, which can be measured directly through money, or by institutionalized forms such as property rights and investments. Economic capital influences the educational choices available to individuals. For example, Lynch and Moran show how the availability of economic capital allows middle-class parents to choose fee-paying schooling or to opt out of the formal school sector entirely [44]. Social capital refers to the social networks that individuals have, including family, friends, and other types of social relationships. Social networks can provide valuable information about educational opportunities and resources. Family social capital, for example, has been shown to relate to school choice [45] and educational achievement [46]. Individuals with strong family social capital may therefore be more aware of various educational paths and have access to advice and guidance from knowledgeable contacts. Moreover, the academic decisions made by both parents and siblings can impact an individual's own choice of study, commonly referred to as the family spillover effect [47]. Cultural capital refers to skills, dispositions, and tastes, but also educational qualifications and cultural goods like books and art. For example, students may believe that they do not belong in a field of education, or that the problems they must overcome make it too risky to participate [48]. In terms of objectified

cultural capital, there is an unequal distribution in learning materials and ways to access them, even in countries where wealth distribution is more equal [49]. Especially with the digitalization of education, students are often required to access their educational materials using computers and the Internet, leading to a digital divide between those who have access to technology, and those who have not.

D. Social reproduction theory

Social reproduction theory posits that social inequality, especially in education, is reproduced from one generation to the next, maintaining the status quo of social hierarchies [50]. This theory suggests that the educational system is designed in ways that reflect and reinforce existing social structures, often disadvantaging students from lower socioeconomic backgrounds. The education system is reproductive through various mechanisms. Foremost, education is capital exclusive, i.e. a predetermined level of capital is required for participation. Recent research shows that capital serves as a barrier for students entering computing fields [51], and that capital relates to participation in computing education for people of various backgrounds [52]. This suggests that students with higher levels of capital are able to reproduce their class position within computing and engineering fields, making it more difficult for people with lower levels of capital to participate and succeed.

E. Gamification theory

While the previous theories listed explain educational attainment from various yet related perspectives, Gamification theory proposes ways to close the educational gap. Gamification theory in educational research focuses on the application of game design elements in educational settings to enhance student engagement, motivation, and learning outcomes [53] [54]. This approach is based on the premise that the motivational power of games can be harnessed to make learning experiences more engaging and effective. In computing and engineering education, gamification of courses has been linked to higher pass rates among students [55], and student motivation [56], while reducing the cognitive load of students learning challenging material.

F. From theory to practice

The various theories mentioned throughout this section have had a significant influence on this game's design. From an intersectionality perspective, each character has their own background story with a variety of social identities, shaping the game decisions which can be made by the players. The base trait points assigned to the characters reflect the various forms of capital that individuals have access to, and it allows them to gain an advantage within the game, altering their life journeys and outcomes. Based on the characters, certain opportunity structures are available which are not available to other characters. And, towards the end of the game, it should become clear that players with higher levels of capital and opportunity structures are able to choose more financially rewarding career paths, highlighting the social reproduction of inequality within this game.

IV. Methodology

The methodology section for this paper involves understanding how to organize a workshop or a class where this intervention is introduced as an activity. The game mechanics are designed to highlight the interplay between individual agency and structural constraints, embodying the principles of educational attainment and the varied structures of opportunity encountered by individuals from diverse backgrounds. The game was designed to engage both students and teachers in computing and engineering fields, particularly engineering and computer science, with the realities of educational disparities.

By simulating the journey through different educational and life outcomes based on varied forms of capital the game offers a hands-on approach to understanding the complexities of opportunity and achievement in computing and engineering education. It underscores the critical need for diversity and inclusivity in fostering innovation and problem-solving. The game was piloted three times, once virtually and twice at the WEEF conference in South Africa and Mexico as shown in fig 1. This interactive tool not only aids in grasping complex educational theories but also highlights the importance of personal effort, policy, and practice in overcoming barriers. A distinctive feature of the game is its end-phase reveal of character backgrounds, intended to prompt reflection on how subconscious factors like privilege, family background, and identity influence educational and career trajectories. Ideal for educational settings, it prepares future computing and engineering professionals to navigate and contribute to a more equitable field.

A. Game Design

The game incorporates a variety of elements including token selection, trait points management, board game mechanics, and the impact of life events on players' progress. The objective of the games is for players to navigate through life's challenges and opportunities, making strategic decisions to accumulate the highest possible trait points across different status bars to give their token the best possible chance at getting admitted into college or a successful career. The game board is designed to simulate the unpredictability of life with events that can suddenly change a player's trajectory. This requires players to be adaptable, adjusting their strategies in response to new information or changes in their or others' circumstances. This dynamic is crucial for teaching players about resilience and flexibility—skills that are invaluable in real life. What follows below is a summary of the key components and how the game is played:

Team Formation and Roles The game can be played in two modes. Independent players or teams with 2-3 players. The player/teams select a token representing a child with a unique set of starting trait points. Team members are assigned specific roles: event logger, trait point tracker, and token mover. The independent player version requires the player to do all roles.

Fig. 1. Game play environment and physical modalities in pilot studies

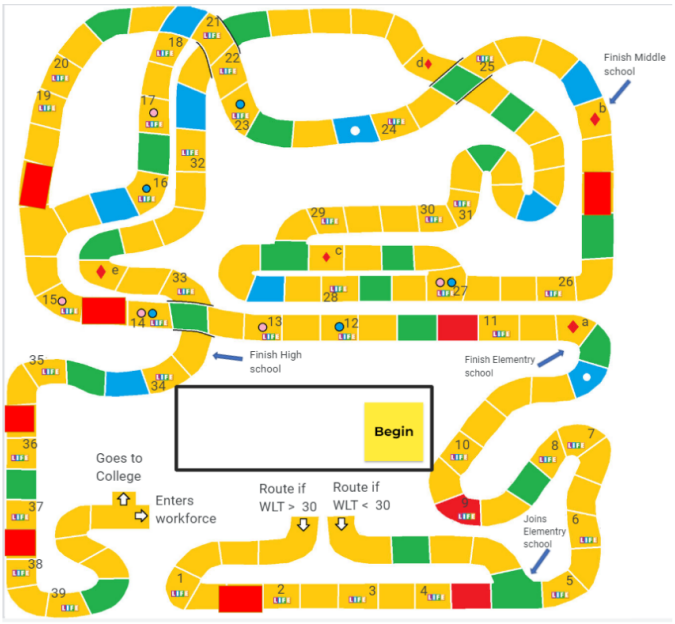

Fig. 2. Board Game Play area with all the components

Fig. 3. How the tokens are presented at the beginning of the game

Teams have at most 1 minute to make decisions during their turn.

Token Selection Modeled after many role-playing games like Dungeons and Dragons or Runescape that have characters with various stats like health, mana, strength, or vitality, the tokens in this game begin with visible attributes of shape (diamond or rectangle), colors (red or blue), and initial trait points reflecting their socioeconomic status, talents, social capital, and economic capital, as can be seen in Fig 3. The players are told to select a token at random with the only instructions being each token represents a child and they each have different skills and strengths. Each token represents a child with a background story that is not disclosed at the beginning of the game.

Forms of Capital The trait points in this game reflect the various forms of capital that are said to influence educational participation and career outcomes [57]. These include:

- Human Capital (Talent): Skills, knowledge, and qualifications obtained through education and experience that enhance an individual's ability to earn a living and succeed professionally.
- Economic Capital (Wealth): Financial assets and resources that can be used to gain educational and social advantages.
- Social Capital (Goodwill): The networks of relationships among people who live and work in a particular society, enabling that society to function effectively. Social capital is crucial for gaining access to resources and opportunities.
- Cultural Capital (Legacy): Non-financial social assets, such as education, intellect, style of speech, dress, or physical appearance, that promote social mobility beyond economic means.

Board Game Mechanics Movement is determined by dice rolls. Tokens gain trait points by landing on specific squares or completing educational stages. As teams move around the

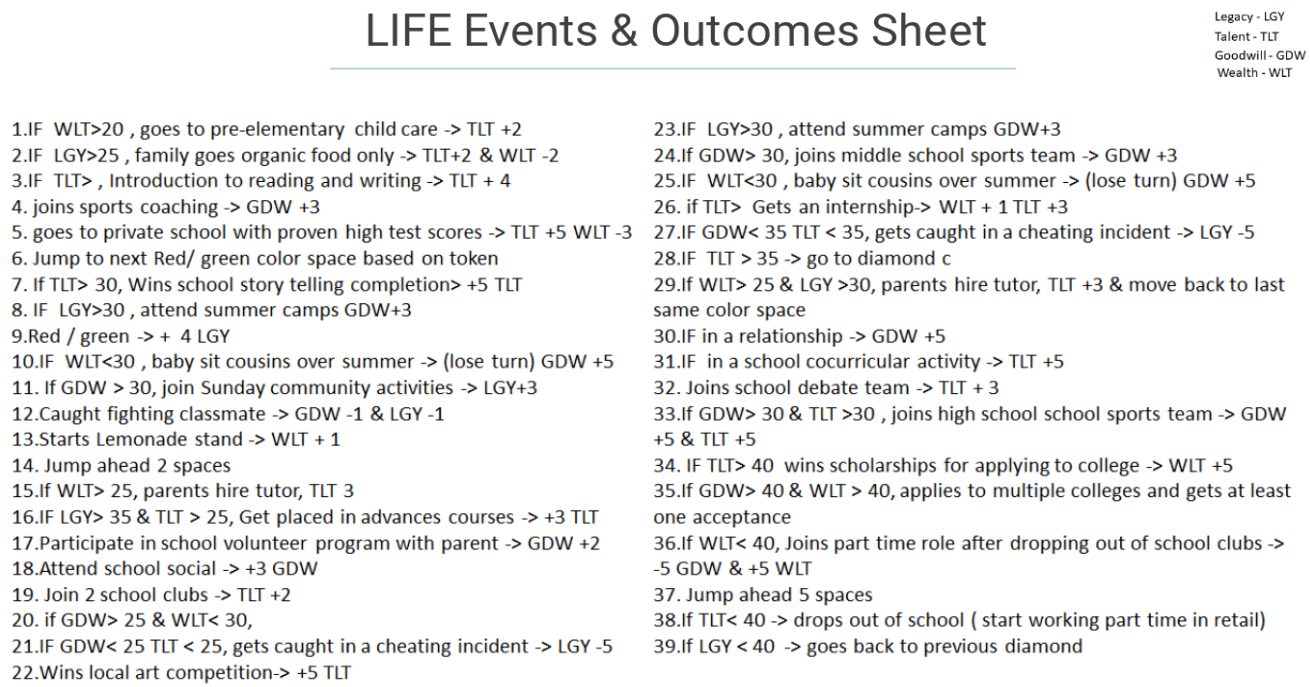

Fig. 4. Life events and Outcomes

board, they encounter various squares that represent different life events or decisions, detailed on Fig 2. These events are triggered by landing on certain squares, with outcomes affecting trait points. These events affect the token's trait points, either increasing or decreasing them based on the nature of the event and the decisions made by the players.

B. Player Dynamics

Throughout the game, players are faced with various decisions at different points on the board. These decisions often require weighing short-term benefits against long-term outcomes, assessing risks, and considering the potential impacts on different trait points. The decision-making process is influenced by the players' initial conditions (token characteristics), the current state of their trait points, and the collective goals of the team. Indirect interactions involve players observing and learning from the outcomes of other players' decisions, adjusting their strategies in response to shifts in the game environment.

Life Decisions, Events, and Outcomes: There are two kinds of game event mechanisms Life decisions (fig 5 and Life events(fig 4). The Life events impact the child's development in various areas and occur every time a player lands on one of the blocks with a number on it. These events can either boost or reduce trait points in Legacy, Talent, Goodwill, and Wealth. Similarly, some of the blocks have different colors that boost different tokens in various ways. Life decisions are similar to life events but have a higher impact on tokens' traits and also provide players agency to make choices based on their token's trait points. The outcomes of these events influence the token's progression and final paths in life, such as career and educational achievements. See Appendix Life Events and Decisions for specific rules and events and their outcomes.

End Game and Path Outcomes At the end of the game, players are shown their life paths based on accumulated capital, reflecting diverse life outcomes in terms of career, education, and socioeconomic status. This phase also serves as a reflection, in which players discuss their characters' backgrounds(fig 6) and how this affected their life journey and outcomes.

C. Data Collection

Upon completion of the game, each team/player is presented with the biography of their token (character). This bio includes detailed information about the character's background, including family, socioeconomic status, and initial conditions. Moderated by the faculty, teams/players reflect on how their character's background might have influenced the decisions they made during the game and how it relates to the outcomes achieved. Facilitate a group discussion to explore the concepts of privilege, opportunity, and the impact of socioeconomic factors on life outcomes. Discuss how awareness of one's background can influence real-life choices and opportunities. Highlight the role of education, social policies, and individual actions in overcoming or succumbing to the challenges posed by one's starting point in life. This game was designed as a part of a sociology of education course with doctoral and master students from various disciplines. The backgrounds

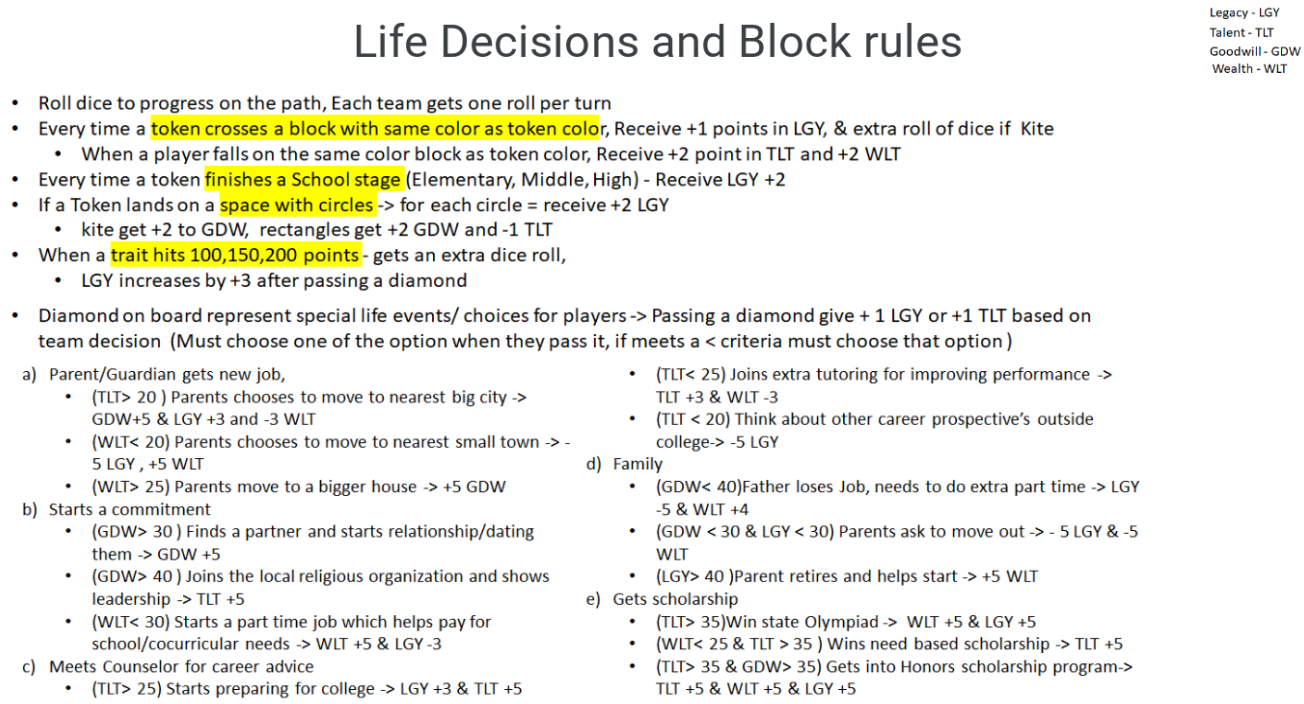

Fig. 5. Life Decisions and Block rules

and trait points were created after discussions in a group format with 8 students in the course who went through a semester-long research course covering various topics under the sociology of education in the United States. The game was piloted three times. The first time was virtually in a Diversity and Equity course with an interdisciplinary cohort of graduate students in the United States. The second and third pilots after modifying the game based on feedback took place at the World Engineering Education Forum (WEEF) in workshop format. the participants at both the workshops included undergraduate and graduate students from across the world. The locations for the workshops were in Monterrey Mexico and Capetown South Africa as shown in Fig 1. The following questions can help with the discussions and reflections.

Reflection Questions

- How did your strategy change after learning your character's background?
- In what ways do you think the character's initial conditions affected their journey and outcomes?
- How does this game simulate real-life opportunities and challenges faced by individuals from diverse backgrounds?
- What lessons can we take from this game to apply to our understanding of society and our interactions with others?

Participants across all pilots shared how the reflection helped them understand the interconnectedness of topics of privilege, capital, and intersectionality. Some also connected how their personal interest in pursuing their current major could have been influenced by their socioeconomic status and the occupation of their parents. Some shared how the game provided them with an opportunity to discuss topics that could have otherwise been challenging in a classroom. They also shared what they would have done differently and how similar decisions might impact their real lives.

V. Conclusion

Classrooms are a reflection of society, and similar to how society has various stakeholders with their independent interests, goals, and privileges, so does a classroom. The stakeholders for a classroom or a course could consist of the teacher, the student, and the space that is facilitating the said course. Often there is a social contract tying the two human stakeholders together in the form of syllabus, degree, performance reports or tests, etc. Still, the space in which the interaction takes place also influences the learning experience and interactions between the stakeholders. For students to truly understand better how concepts like privilege and identity impact the student experiences in computer science and engineering, it is crucial to observe and explore systemic level factors that influence how a course is designed and taught, how students experience the course through patterns in their perception with an intersectional lens and how these factors influence the overall representation of people in various educational institutions and programs. The game proposed in this paper does this by having each player, represent a character with a hidden socioeconomic background, strategies to maximize educational outcomes and life opportunities for their token.

Fig. 6. The token background stories that are given to students before reflecting on the game experience

The game operationalizes the multifaceted concept of capital into four distinct types of character stats —Talent (human capital), Wealth (economic capital), Goodwill (social capital), and Legacy (cultural capital and socioeconomic class) — to underscore the diverse resources that influence educational attainment and life opportunities. The game mechanics are designed to highlight the interplay between individual agency and structural constraints, embodying the principles of educational attainment and the varied structures of opportunity encountered by individuals from diverse backgrounds. A distinctive feature of the game is its end-phase reveal of character backgrounds, intended to prompt reflection on how subconscious factors like privilege influence educational and career trajectories. This reflection serves to illuminate the relationship between capital, opportunity, and education, demonstrating how external factors shape educational experiences and pathways. "Game of Life: Educational Pathways" is designed to engage both students and teachers in computing and engineering fields, particularly engineering and computer science, with the realities of educational disparities. This game-based approach to learning ensures that the next generation of computing and engineering professionals is not only technically proficient but also socially conscious and culturally competent, ready to lead and transform their fields.

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