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Developing Critical Thinking, Collective Creativity Skills and Problem-solving through Playful Design Jams

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Abstract

Collaborative problem-solving skills are paramount within the context of 21st-century learning skills development. These skills include critical thinking, creativity, collaboration and communication (4C's). This research examines the elements of motivation, play and collaborative practice within a design activity, called *Design Jam*. Design Jams, such as Global Service Jams and Global Sustainability Jams, utilise design thinking to explore possible solutions to complex problems through interdisciplinary working in small groups. This paper presents a three-phase mapped process for Playful Design Jams (PDJ) that incorporates playful elements and supports the development of positive interdependence within team-based activities. The experiences of participants within nine separate PDJs were gathered to explore whether they engaged with the 4C's during the process. The participants reported that they felt motivated and that the PDJ improved their creativity, critical thinking, communication and collaborative engagement. This paper contributes to theory and practice in the facilitation to advance thinking skills and creativity. Future studies are suggested to examine the impact on long term development of participants' 4C's in formal education.

Keywords: Design Jam, Play, Collaboration, Communication, Critical Thinking, Creativity, 21st Century Skills, Group Work

1. Introduction

Contemporary design practice, situated within a global economy, is beginning to shift from project-specific collaboration to ever-more collaborative models. Professional designers collaborate within interdisciplinary teams of various experts and stakeholders to address multifaceted, wicked problems like affordable housing, sustainability, climate change, healthcare and democracy through transformative design (Burns et al., 2006). Grappling with these complex challenges highlights key future-focused skills required of designers, and most others, which include, 'critical thinking and problem-solving, creativity and innovation, communication and collaboration' (Susantini et al., 2018: p.1). Collectively, these skills are often referred to as the 4C's. Different future-focused skills and knowledge lists have been presented, such as those from Romero et al. (2015), which include social and cultural skills, complex problem-solving, self-management and direction skills, the ability to navigate in a globalised context and life-long learning among others, in addition to the 4C's.

There is an emerging need for higher education to prepare university students for new types of complexity and uncertain environments constantly in flux. This challenge must be explored as collaboration within groups offers an opportunity to facilitate other future-focussed skills, such as interpersonal skills and empathy. Collaboration requires communication, 'about intentions, ideas, visions and knowledge' (Vyas et al., 2013: p.415). Collaborative groups have also shown significant critical thinking skill development - often with longer information retention than those working as individuals (Susantini et al., 2018). Critical to education that focuses on developing 21st century skills is the recognition that diverse groups of individuals have tremendous creative potential; perhaps even more so than the group members as individuals (Paulus & Nijstad, 2003). Collective creativity is defined as the series of interactions, knowledge sharing and prompts that happen during collaborative engagements, leading to new ideas, approaches and discoveries (Parjanen, 2012). These creative experiences in a group may not necessarily have occurred if individuals were by themselves. Critical thinking - as a major skill required in the '21st century workforce' - can be expertly facilitated by collaboration, however, 'many commentators argue that education systems have been slow to respond to the changing environment and still emphasise information transfer over the development of skills and capabilities' (Conneely et al., 2013: p.2). Interdisciplinary group collaboration, although well practised in the design industry

(Design Council, 2007), has not always been implemented effectively in education. Although many academics and teachers have argued the importance of collaboration as part of learning and teaching, small group interdisciplinary teamwork is not always implemented effectively in education (Head, 2003; Design Council, 2007).

This study introduces the Playful Design Jam (PDJ) process as an effective approach to teamwork that incorporates playfulness, physical engagement and experiential learning. The paper interrogated the theoretical characteristics of a Design Jam and aimed to establish whether the experience engaged participants in the 4C's. Design Jams brings diverse individuals together, usually for 48 hours to co-design a product and service solution to local and global challenges. Design Jams represent collaborative and creative learning opportunities, which can be external to the formal education programme or designed as part of it, through creative facilitation. Findings from questionnaires and semi-structured interviews with participants of nine PDJs are discussed in this paper. The majority of participants were design students (53 in total), both undergraduate and postgraduate, as well as 24 young professional individuals (ages 23-35) from the general public. Participants reported on their experiences during the PDJs, which highlight their engagement with critical thinking processes, creative explorations and communication through collaborative team activities. Participants showed high levels of motivation and engagement in group work and collaboration during the PDJ. They reported that they felt the event improved their creativity, critical thinking, communication and collaborative engagement (4C's). The measurable effect on long-term development of the 4C's and higher order skills fell outside the scope of this study as participants reflected only on their experience during the event. Some anecdotal findings were shared by participants relating to their long-term skills and capability development. However, this would require additional investigation.

The paper contributes a clear theoretical mapping of PDJ relating to the concept of play, positive interdependence and factors that can enhance team affiliation. The participants reported that they experienced engagement with all 4C's during the process. Given the ability to actively engage participants in all 4C's within a single, holistic process the PDJ offers educators and creative facilitators a method to use within interdisciplinary collaborative environments. Finally, critical reflection and ways for further enhancement

are concluded, to improve future teaching, learning and facilitation practice for collaboration and thinking.

2. Literature Review

2.1 Design Jams

Design Jams are intensive design workshops, usually 48 hours in length, during which a diverse group of individuals co-design product and service solutions to global challenges, which could be social, economic or environmental in nature. Design can be described as a creative process during which something new or novel is conceptualised (Henriksen, Richardson & Mehta, 2017). Design Jams were inspired from Hackathons where various experts from the field of informatics and UX come together and work intensively on developing new software products (Briscoe & Mulligan, 2014; Authors 2 & 1, 2014). Since 2011, the Service Design communities have been using this format for Global Service Jams and Global Sustainability Jams. The Global Jams (http://globaljams.org) are non-profit events run by a small group of global organisers who offer inspiration, basic rules and a central online platform for regional Jams. The 'Jammers' (the name given to participants) choose their projects and teams, and discover, develop and prototype solutions throughout the event (Snow et al., 2019). Guidance is offered by facilitators and mentors - who usually have expertise in project management, creative and design related fields. Each team is expected to upload information and evidence of functioning prototypes of a product, service or system on the Global Jam web platform: ranging from 'low tech to high tech', along with an action plan to take forward (Kuzmina et al., 2016: p.6).

When exploring the potential of a Design Jam to develop 21st century learning skills, the focus was placed on how members of the teams collaborate and communicate to conceptualise creative solutions to real world problems and think critically. The term '*distributed creativity'* has been used to describe a group of individuals working together, so come up with a unique, new or novel product (Sawyer & DeZutter, 2009: p.82). Design Jam activities are grounded in distributed creativity activities, which are based on real-life experiences and draw from observation, interaction, communication and various thinking modes (Bezanilla et al., 2019). To place the potential of Design Jams to develop creativity and critical thinking - as part of 21st century skills - in context, one must first consider the nature of Design Jams. This includes requiring individuals to work as a

creative team, leveraging positive interdependence to engage in cooperative learning and problem-solving.

2.2 Collaborating as a creative team

Collaboration capability is a multi- and cross-level concept that can be used to understand and analyse the team's relational interactions on different levels: individual, team, intra-organisational, organisational and inter-organisational. Blomqvist and Levy (2006: p.39) define collaboration capability as one's 'capability to build and manage network relationships based on mutual trust, communication and commitment'. Salas et al. (2005) propose that three coordinating mechanisms support effective teamwork, namely, mutual trust, closed-looped communication and shared mental models. Communication ensures that every collaborator knows what they are doing and when they have to do it, which enhances the level of trust and promotes teamwork within a group (Ruppel & Harrington, 2002).

It is important to define the similarities and differences when referring to a group or team of individuals, which forms the foundation for references to teamwork or group work. In this study the two concepts are seen as complementary, building on Homan's (1951) definition of a 'group' as a number of people who communicate directly (face-to-face) with one another for a set duration of time, and 'team' as defined by Katzenbach and Smith (1993) as a few individuals who work towards a common goal or outcome, often with a complementary skill set. Teamwork thus describes the ability of a group of individuals to collaborate to complete the defined challenge (Williams et al., 2006). At the core of successful teams are behaviours that facilitate effective team member interaction (Beaubien & Baker, 2004). Teamwork skills are a vital part of the design graduate portfolio (Tucker, 2016), and skills related to individuals working well in a group are increasingly valued by employers (Felstead et al., 2013). Graduates need to be equipped with the skills and knowledge that would help them navigate a global context and transition from the classroom to the workplace (Cranmer, 2006; Andrews & Higson, 2008; Mason et al., 2009; Macdonald & Macleod, 2018). One of these skills is the ability to function as part of a creative team (Mishra & Mehta, 2017).

Studies regarding group creativity have often been based around organisational innovation (Paulus & Nijstad, 2003). The more open the challenge, the more groups can

engage in creative exploration and contribute innovative ideas. Collective creativity is experienced when a group of individuals interact. As a result, the group triggers unique and new concepts, insights and interpretation - often more unusual and novel than those an individual would have imagined by themselves (Parjanen, 2012). Collaborative creativity is also influenced by individual factors such as familial experiences and one's culture, as well as the environment (Paulus & Nijstad, 2003).

2.3 Positive interdependence, cooperative learning and critical decision making through creative facilitation

Willingness to participate in a group activity is linked to positive interdependence. Johnson and Johnson (2008) included positive interdependence in the conditions for structured cooperative learning. In this context, the definition of cooperative learning is taken from Cuseo (1992), who defined it as: "a learner-centred instructional process in which small, intentionally selected groups of 3-5 students work interdependently on a well-defined learning task". This definition speaks to the basic engagement principles of a Design Jam. Cooperative learning is effective but requires five conditions including; positive interdependence, individual accountability, promote interaction, interpersonal and small group skills and group processing (Johnson & Johnson, 2008). According to Johnson et al. (1995: pp.31), positive interdependence occurs 'when one perceives that one is linked with others in a way so that one cannot succeed unless they do (and vice versa) and/or one must coordinate one's efforts with the efforts of others to complete a task'. This statement resonates with the ability of group activities to yield higher levels of creativity than the 'inner mental processes' of a single individual (Sawyer & DeZutter, 2009: p.83). The perception of being linked to others is grounded in how individuals value collaboration, and group membership is linked to higher levels of information sharing, interaction and learning (Williams et al., 2006). Consequently, students encourage each other to complete tasks and reach the group's goals (Johnson et al., 1995). Creative facilitation explores the inclusion of creative activities and thinking in education from both a student and staff perspective, and offers a shift from more traditional pedagogy. Baillie (2006: p.154) highlights the need for a curated space that is conducive to creative exploration:

> There are no rules to creative thinking - however the skill of the facilitator is to create the atmosphere which is conducive of idea generation, as well as selecting the most

appropriate technique, for the participants, in their context and with their particular problems to solve.

The need for a supportive environment is a requirement of both facilitated creative education sessions and Design Jams. Creative problem-solving, however, has gained ground in many different disciplines, as the practice combines creativity and innovation to find more suitable and desirable solutions to a range of challenges (Cruickshank & Evans, 2012). The creative facilitation allows for more collaborative interactions and more 'feasible ideas' to emerge (Rickards & Moger, 2006: p.7). Facilitators will also bring preferences and bias into a creative session. For this reason it is critical for facilitators during a Design Jam to retain a sense of neutrality, defined by Wróbel et al. (2020: p.8) as 'consisting of three interdependent elements: impartiality, equidistance, and fairness'. This practice supports the teams to collaborate and communicate more openly, and creates an environment where creativity and critical enquire can flourish. Positive interdependence, cooperative learning and critical decision-making are factors influencing teamwork and the development of the 4C's during a PDJ. Creative facilitation is one way to achieve these, and Design Jams can be perceived as a method of creative facilitation, linked to activities such as prototyping with different materials and objects, idea generation, role playing and dramatisation of different scenarios.

2.4 Criteria relating to creativity, critical thinking, collaboration and communication

In order to explore collective creativity, a systematic review by Moiranoa et al. (2020) was analysed. The characteristics noted, were established through a literature review of 61 recent contributions on interdisciplinary collaboration for creativity. The study identified the following dimensions to consider: individual, collective and environmental (Moiranoa et al., 2020). Findings from Harvey and Kou (2013) were also reviewed in line with creativity facilitation. Working in a group on a team challenge, such as those posed during a PDJ, offers more 'adaptability, productivity, and creativity' than one would expect from an individual working alone (Salas et al., 2005: p.556). Criteria that contribute to the collaborative nature of the interaction, expressed as team collaboration and as the collective inquiry was reviewed through the findings of Patel, Pettitt and Wilson (2012). These criteria draw from their seven main collaboration factors, namely: context, support, tasks, interaction processes, teams, individuals and overarching

factors. The barriers to collaboration identified were explored as indicators to consider when aiming to develop collaborative skills (Patel et al., 2012).

Working collaboratively on a real world challenge is at the centre of the Design Jam experience. The process of developing critical thinking through complex problem-solving is not a simple one. Learning how to think critically can be a very individual experience, but six categories have been defined as supporting the general development of critical thinking skills. These include 'Analysing/Organising; Reasoning/Arguing; Questioning/Asking oneself; Evaluating; Taking a position/Taking Decisions; and Acting/Compromising' (Bezanilla et al., 2018). Within a Design Jam, communication is crucial. It facilitates both creative exploration and critical thinking through the questioning of emerging concepts and negotiating which idea to take forward and exercising informed decision-making. Criteria that support the development of open and supportive communication within teams are explored through the systematic review of literature by Tiferes and Bisantz (2018), and the earlier, more design-centred findings of Suri and Marsh (1997). The findings from the above mentioned literature - in relation to criteria and concepts that support the development of 4C's - are mapped in Table 1. Appendix 1 provides a more detailed explanation of the criteria.

Table 1: Collective Creativity, Critical Thinking, Collaboration and Communication Criteria

Emerging criteria and associated 4Cs	Relates to the development of 4C's
4CC1: Different expertise, perspectives and knowledge celebrated in the team, and transdisciplinary knowledge sharing facilitated and supported (Patel et al., 2012; Tiferes & Bisantz, 2018; Moiranoa et al., 2020)	*Creativity, Collaboration, Communication*
4CC2: The activities should support social bonding and shared experiences (Suri & Marsh, 1997; Moiranoa et al., 2020)	*Creativity, Communication*
4CC3: A common language must be used and developed to allow for effective communication (Patel et al., 2012; Moiranoa et al., 2020)	*Creativity, Collaboration, Communication*

4CC4: Activities must be focussed around a common goal or solving a challenge (Suri & Marsh, 1997; Patel et al., 2012; Moiranoa et al., 2020)	*Creativity, Collaboration, Communication*
4CC5: The process must allow for acceptance and recognition of an individual within the team, but not at the cost of collaboration (Patel et al., 2012; Moiranoa et al., 2020).	Relates to: *Creativity, Collaboration*
4CC6: The process must support open and unrestrictive exploration and various modes of representation to communicate findings (Suri & Marsh, 1997; Tiferes & Bisantz, 2018; Bezanilla et al., 2019; Moiranoa et al., 2020)	*Creativity, Critical Thinking, Communication*
4CC7: Playful, well-structured activities must support active learning (Bezanilla et al., 2019; Moiranoa et al., 2020)	*Creativity, Critical Thinking*
4CC8: The process must encourage discussion and varying modes of communication (Suri & Marsh, 1997; Patel et al., 2012; Tiferes & Bisantz, 2018; Bezanilla et al., 2019; Moiranoa et al., 2020).	*Creativity, Critical Thinking, Collaboration, Communication*
4CC9: Time constraints improve creative thinking (Tiferes & Bisantz, 2018; Moiranoa et al., 2020).	*Creativity, Communication*
4CC10: Activities must happen in a supportive and resources environment (Patel et al., 2012; Moiranoa et al., 2020)	*Creativity, Collaboration*
4CC11: Facilitation and support must encourage engagement and mediate conflict (Patel et al., 2012; Moiranoa et al., 2020)	*Creativity, Collaboration*
4CC12: The influence of technology must be managed to ensure it supports discussion and problem exploration; not hinders it (Patel et al., 2012; Moiranoa et al., 2020)	*Creativity, Collaboration*
4CC13: The process must allow for 'free' generation of many ideas before they are evaluated and a final selection made (Harvey & Kou, 2013; Bezanilla et al., 2019)	*Creativity, Critical Thinking*

3. Mapping the context of a Playful Design Jam experience

Global Service, Sustainability and GovJams, initiated by Markus Hormess and Adam Lawrence, utilise design thinking to immerse participants in problem-solving interdisciplinary working in less than 48 hours (Kuzmina et al., 2016). Positive interdependence to facilitate cooperative learning during this fast-paced engagement is a key factor to consider in PDJ experiences. Olsen and Kagan (1992, cited in Dörnyei, 1997) identify five principal ways (labelled as M1 to M5 in Figure 1) to achieve positive interdependence during teamwork. These factors can be noted in a PDJ experience and allow participants to engage with group learning. According to Rieber (2001), learning and motivation can be achieved through designing learning environments as social places where the resources, time and reasons are available to nurture, support and value such learning. Correspondingly, during a PDJ environment and spaces are created to allow for social interactions and team activities. Participants fulfil different roles throughout the process, and decide on their team's performance and goals. As a result, the success of the final design solution is dependent on how well the group functions as a team (M2). Simply functioning as a team only represents one aspect of working collaboratively. In the educational context, a learning process should be prioritised and supported in PDJs. Deutsch (1949) suggests that group cohesiveness has a positive impact on further motivation to learn in a group and Dörnyei (1997) summarises the factors that can enhance affiliation (labelled as M6 to M17, in Figure 1).

Figure 1. Five principal ways to achieve positive interdependence (M1-5) and attributes of successful cooperative learning (M6-17).

As opposed to passively receiving information, Design Jam activities create an environment of sharing and conveying knowledge in a group learning context. An example of this is working closely together on a challenge during a PDJ. Challenges chosen as topics for Design Jams also present participants with the opportunity to engage in rewarding experiences based in real world various social, environmental and developmental contexts. This helps develop communication skills within the group and links to 'action learning' processes in which a student works in a group on real world challenges, becoming more critical throughout the process (Charlesworth, 2018).

Since solving real world problems requires application of critical thinking, acquiring its skills prepares students for the world outside of school in the workplace and in interpersonal and social contexts where decisions are to be made carefully and independently… (Sasson, Yehuda & Malkinson, 2018: p.205)

An understanding of critical thinking skills, defined by Kuhn (1991), includes being able to deduce options from understanding and knowledge, being able to justify one's beliefs and theories, being able to imagine and explore alternatives through a 'weighing' of evidence and finally to offer 'counter-arguments' (Fung & Howe, 2012: p.102). These characteristics contribute to the development of collaboration, communication and critical thinking during a Design Jam, all 21st century learning skills. Design Jams are structured around these skills, along with creativity, and support collaborative, team environments. Learning within a small group leads to a sense of community, creating a shared understanding of the goal of the group and a common sense of mutual benefit (Head, 2003). Meyer and Land (2006) argue that students might feel challenged since this process of learning requires a transformation – one must change oneself, and thus lose part of one's old self. A resistance to take part could be mediated by emphasising 'problem ownership' (Baillie, 2006: p.153). This will help participants feel engaged and part of the larger Design Jam experience.

Another key characteristic of Design Jams is the presence of multiple playful elements that are fundamental to PDJ experiences. Learning and effective teamwork can be achieved through play, as it motivates students to question their preconceptions (Macdonald & Macleod, 2018), conventions and habitual behaviour (Rice, 2009). Play has been identified as a powerful mediator for learning and appears to be an applicable 'motivating strategy' to develop positive attitudes toward learning (Rieber, 1996; 2001). Play has also been shown to assist in the development of creative skills – another 21st century learning skill (Davies et al., 2013). As the Design Jam experience aims to promote social cohesion and collaboration, the influence of play was considered as, 'when people play, they become attuned to each other' and 'groups pull together in pursuit of a common goal' (Brown, 2009: p.134). In this project, the concept of play is defined as a series of playful characteristics integrated into the instructional design to make learning and group work experience more appealing. From reviewing the literature related to play (Levy, 1978; Henricks, 1999; Brown, 2009; Khazaei, 2018), and the use

of humour in learning (Kher et al., 1999; Pentaraki & Burkholder, 2017), characteristics of play to create a positive learning experience are summarised in Figure 2.

Figure 2. Characteristics of play to create a positive experience in learning (adapted from Levy, 1978; Henricks, 1999; Kher et al., 1999; Brown, 2009; Pentaraki & Burkholder, 2017; Khazaei, 2018)

Henricks (1999) comments that one of the qualities that differentiate the act of play from 'normal life' activities is active and deep engagement in an experience, which reflects part of a process referred to as experiential learning. Experiential learning is learning through doing and reflection on doing. During a PDJ, play is critical and can be noted throughout the process. During prototyping, the participants can incorporate various playful elements to create and demonstrate their ideas. These include embodied performances and working with toys and playful material to construct ideas (P1, P2, P3, P4, P5). Given the nature of learning being recursive, cyclical and iterative (Kolb, 1984), serious play in education enables students to engage students in some meaningful experience as early on as possible (Rieber, 2001). To understand the interplay of these factors, the indicators of positive interdependence and attributes of the successful cooperative learning (Figure 1) presented and the characteristics of play (Figure 2) were mapped on to the PDJ process. As illustrated in Figure 3, the activities undertaken in the PDJ can be grouped in three main phases, with a number of critical moments of engagement relating to participants' experience:

- 'Before the design jam' aimed at setting up the objectives and conditions required to start the jamming process. It is suggested that facilitators can begin with preparing the seven-ingredient 'recipe' of the Design Jam. Fundamental ingredients include people (local organisers, facilitators, mentors, jammers, local partners and sponsors), location, materials, design tools, food and drinks, games and props (Authors 1 & 2, 2017). During this phase, venue preparation is critical as an environment's set up needs to support social interaction and must include the resources, materials and equipment to encourage and support the interaction. As Rieber (2001) noted, these factors impact learning and motivation.

- 'During the design jam' aimed at implementing the activities that take place in the design process, including the kick-off presentation, the secret theme revelation, the brainstorming session, the iterative ideation - prototyping - testing phases, the finalisation of the project and presentation. This process includes a number of specific steps which draw from playful interaction and support cooperative learning. During the *design challenge identification* phase, participants work collaboratively to critically engage with the topic and decide on a team challenge to pursue. This process requires communication, group negotiation and collaboration skills to identify common goals and a way forward. *Ideation* provides participants with an opportunity to creatively explore the challenge in their team using a mix of creative methods and materials. During *prototyping* and *testing,* the group moves through phases of making and evaluating. The phase refines ideas and requires participants to evaluate their decisions when reflecting on their process critically. These moments mirror the design process and bring together a range of skills and thinking processes.

- 'After the design jam' activities aimed at communicating and disseminating the design ideas and solutions, activities and critical discussion achieved during and at the end of the event. The final presentation allows participants the opportunity to share ideas using a range of creative, playful methods if they wish including props and role-playing.

Figure 3. Playful Design Jam (PDJ) process integrates the characteristics of play and teamwork motivation enhancers

4. Research Methods

To explore the experiences of PDJ, Pre- and Post-Jam questionnaires and unstructured observations were used. In addition, semi-structured interviews were carried out after PDJs to map out the teamwork processes and identify whether PDJ experience could contribute to the development of the 21st century learning skills of 4C's, including communication, critical thinking, collaboration and creativity.

4.1 Participants

Recruitment involved placing advertisements around the university, by email, word-of-mouth, and using posters in community centres and Internet-based Global Jams

platforms. The convenience sampling strategy was adopted with the group being readily available and willing to participate in the Jam and data collection. In total, 77 Jammers (including 53 design students enrolled in either undergraduate or postgraduate courses and 24 young professionals aged 23-35 years) participated in the Pre-Jam questionnaire, 57 (35 design students and 22 young professionals) in the Post-Jam questionnaire, and 27 in the interviews.

4.2 Data Collection

Pre-Jam questionnaires contained questions of general demographic information. Post-Jam questionnaires included closed-ended questions (requiring Likert scale responses from 'strongly disagree' to 'strongly agree') and open-ended questions that prompted Jammers to respond holistically on their experience. Jammers of different ages, educational and cultural background, study and work experiences were observed during the events. Unstructured observation (Bryman, 2016) was used during Jams to document the use of design tools, focusing on the teamwork process and development of the 4C's in the Jammers. Semi-structured interviews were conducted several months after the events to gather Jammers' reflective insights. These Jams were organised between 2013 and 2017.

4.3 Data Analysis

Data analysis consisted of three stages (coding, matrix and, mapping and clustering), allowing for a data display and conclusion (Miles and Huberman 1984). From the data analysis, two discussion points emerged: (1) facilitators' observation and reflection on the development of Jammers' 4C's within the PDJ process and (2) Jammers' experience and perceptions of the PDJ in developing 4C's. The results from each method are referred to by the prefix *Pre-, Post-* (e.g. POST-01) and *Interview-* (e.g. INTERVIEW-01) respectively.

5. Results

5.1 Facilitators' Observation and Reflection on Development of Jammers' 4C's

The phases and activities have been undertaken in the PDJs to inform the development of 4C's and enhance collaborative teamwork and learning in groups from three angles: the collaborative group development, motivation and play characteristics (Figure 4). A

more detailed description of the PDJ phases and activities along with characteristics and their impacts on the 4C's is provided in the following sections. Activities that formed part of the creatively facilitated process include rotational brainstorming, working with props and games, as well as prototyping.
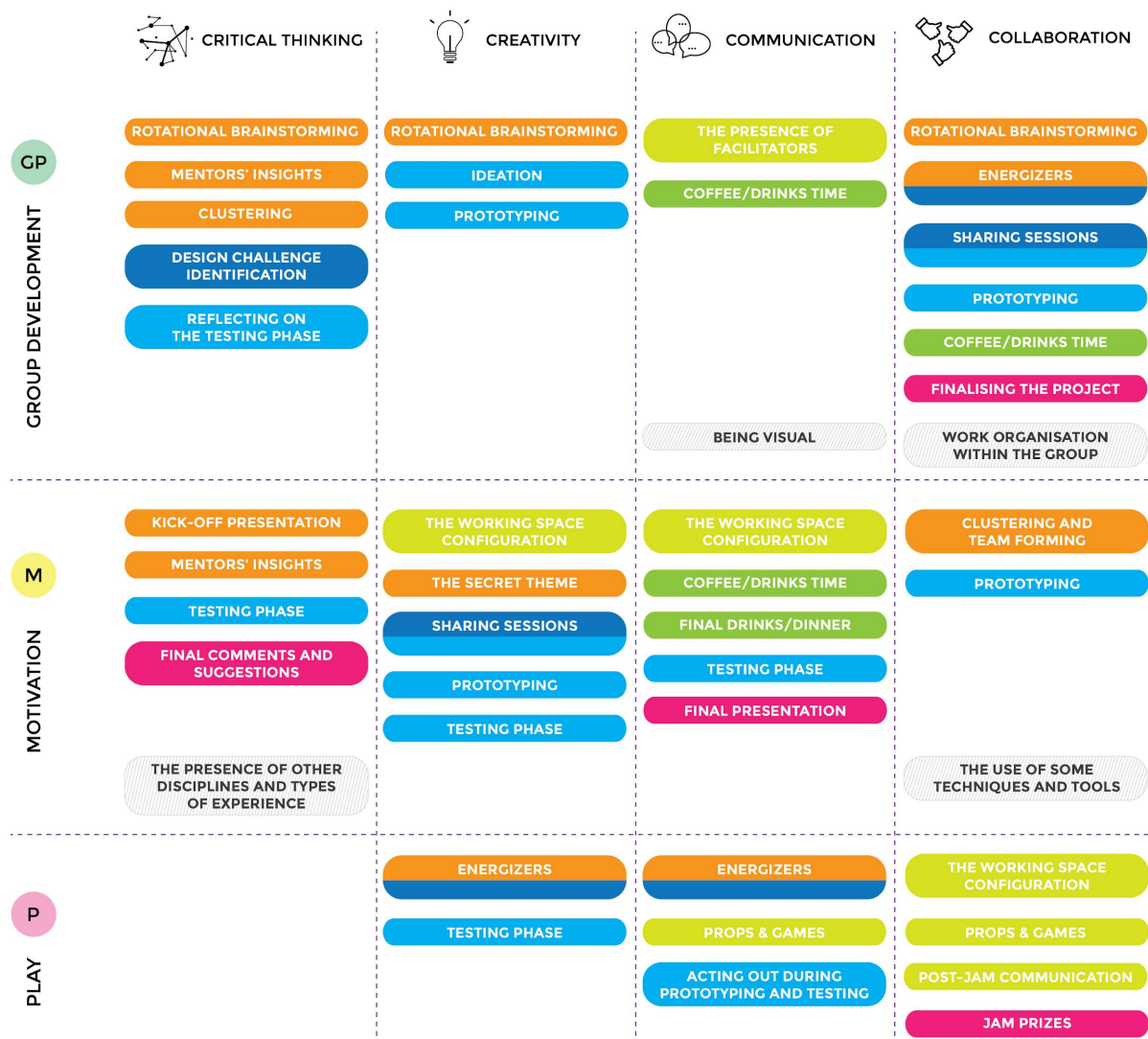

Figure 4. Design Jam's Playful and Team Activities Linked to the 21st Century Learning Skills - 4C's

5.1.1 Developing Critical Thinking skills

The intersection of critical thinking and the group development was facilitated through the *Rotational Brainstorming* and *Design Challenge Identification* group activities.

In the *Rotational Brainstorming* (Figure 5), Jammers were invited to reflect and brainstorm in rotation on the themes that were provided by the PDJ mentors or facilitators. Placing themes on the walls or floor at a certain distance allowed Jammers to take time to view and discuss the themes in small groups. Jammers were required to use post-its to document emerging issues in their discussion in keywords and key questions before moving to other groups. Rotational brainstorming allowed the participants to discover different ways of thinking and new thoughts. It stimulated each participant in seeing and understanding issues from different perspectives. Rotational brainstorming requires a great effort to connect topics and questions emerged from collective discussions. Participants should apply creativity and contribute ideas without being influenced by others. This way of engaging may lead to a more systematic and critical way of thinking.

Figure 5. Rotational Brainstorming

Figure 6. Identifying the Design Challenge.

Design Challenge Identification (Figure 6) required critical thinking from the team to identify and agree on a problem to solve. Jammers in small groups discussed and wrote the design challenge down into a simple and clear sentence that a 5-year old child could understand before presenting to the large group.

Another critical process related to *Reflecting on the Testing Phase* started with the examination of results from the testing phase. During this period, the group members must review their design proposal, adjust strategically what does not work and add what is missing. From a motivational perspective, the multidisciplinary environment contributed to the event and critical engagement among facilitators and Jammers. The variety of participants stimulated new conversations and new ways of thinking around the same issue or problem.

5.1.2 Developing Creativity Skills

The secret theme of the Design Jam represented an element of surprise and created a shared feeling of suspense among all participants in the group. As the starting point of the design process, it motivated the participants to enjoy the path and discover the others' ideas. At the core of the Jam is the *Ideation Phase*, during which the groups generated ideas and explored different ways to solve the same problem. This process required creative and lateral thinking. Once the group identified possible solutions, they started to produce prototypes.

In a PDJ, facilitators aimed to enrich participants' imagination by offering recycled material and experience in abundance. Prototypes were usually lo-fi models and mock-ups that were made of recycled materials and sometimes Lego/Plasticine. The capacity of bringing ideas to life in tangible prototypes out of a recycled and limited selection of materials relied on creativity and imagination. During the *Prototyping Phase* (Figure 7), Jammers understood their design idea better through making and communicating with their team members, and thus identified gaps and removed inconsistencies in the design solutions. Jammers also sought to tackle complex problems which required systems thinking and creativity to connect each component of the same solution.

Figure 7. Prototyping

Energizers were designed to boost the participants' creativity, especially when they got stuck in the problem-solving process. *Energizers*, as *ice-breakers*, were dynamic and playful activities to warm up a group of people who did not know each other before. Jammers interacted with each other in dance and movement, role playing, drawing and simple games (Figure 8).

Figure 8. Energizer

Sharing Sessions (Figure 9) occurred in decisive moments of the PDJ process. The teams were expected to present their design achievements, receive and give feedback to each other, from the design challenge to ideas to prototyping and testing results. These sharing moments provided chances for individual creativity and particularly collective creativity to emerge and motivated each team to do more and achieve greater results.

Figure 9. Sharing sessions

Building on the sharing sessions, the *Testing Phase* (Figure 10) allowed for prototypes to be tested with potential users (ideally outside the room), and thus the immediate feedback could be obtained by the group. The testing encouraged the teams to improve and find the best way to solve the problem identified with a playful mindset, where trying

something on the border of the ridiculous was sometimes even encouraged. Being in the same room to work, where every conversation is audible, and every action is visible, enhanced participants' motivation and engagement - and thus group creativity - due to its collective nature of PDJ.
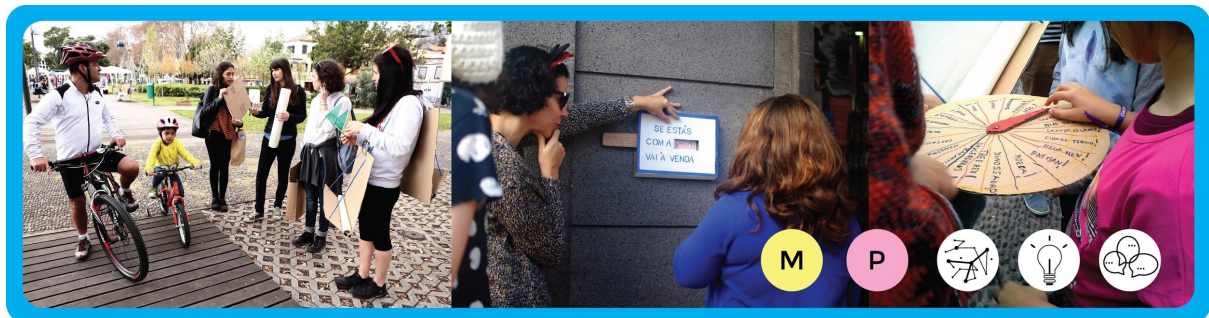

Figure 10. Testing phase

5.1.3 Developing Communication Skills

Drinks and Coffee Breaks (Figure 11) represented convivial moments where the group members could bond. This social aspect impacted positively on the teamwork and internal group dynamics. These breaks also allowed participants to communicate with each other about their design ideas and something that went beyond the Jam theme and design problems. Getting out of the design process for a bit allowed participants to motivate themselves in working with new people and uncover shared interests.

Figure 11. Coffee breaks

While working, *Being Visual* (Figure 12) was a critical communication strategy - from post-it notes with keywords and key questions to sketches and mock-ups. All these were fundamental for the team members to understand each other and be aligned during the whole design process.

In *Role Play* and *Acting Out* the contexts (Figure 13), Jammers performed a role and acted out actions, interactions and emotions along the journey the potential users were expected to go through in the solution-in-use scenario. These techniques allowed for different communication styles —including movement, body language and use of props — as part of creativity.
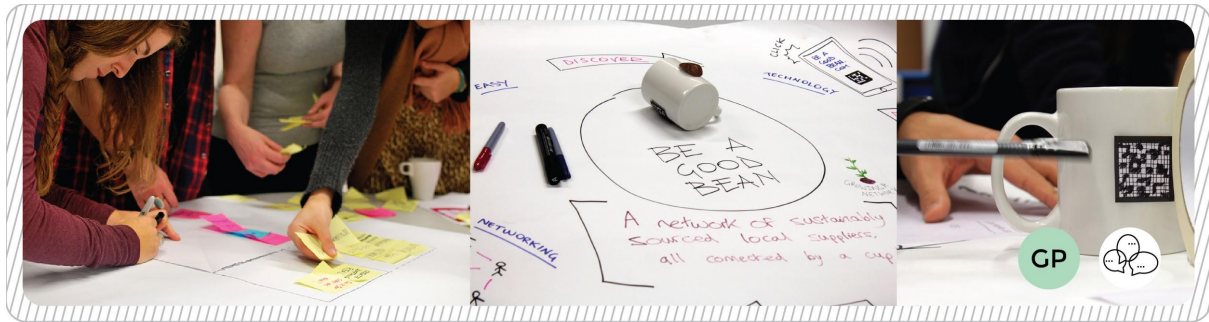

Figure 12. Visual communication during the process

Figure 13. Acting out the contexts

Props (a rubber chicken, or wigs, for example) (Figure 15) as objects allowed everyone to have the right to talk and act, and drew people's attention in order to give attention to speech or action. The use of *Props* encouraged inputs from all participants, contributed to comfortable communication and dynamic balancing within the group, and helped the participants to communicate their creative ideas and critical thinking in an aesthetic way to themselves and the group.

Figure 14. Props aided communication

The presence of facilitators helped the teams to focus on their design process and keep up with the time schedule, and they encouraged healthy dialogue and introduced activities and techniques such as role playing, acting out contexts to ease conflicts emerging among team members in brainstorming and prototyping. This helped the groups focus on the design process. The *Testing Phase* encouraged the participants to get feedback from a wider group of people. When positive feedback was received from external people not participating in the Jams, Jammers became more confident in their creative capacities, both as individuals and a group - which motivated them to work in line with the PDJ's tight schedule and improve their design solutions.
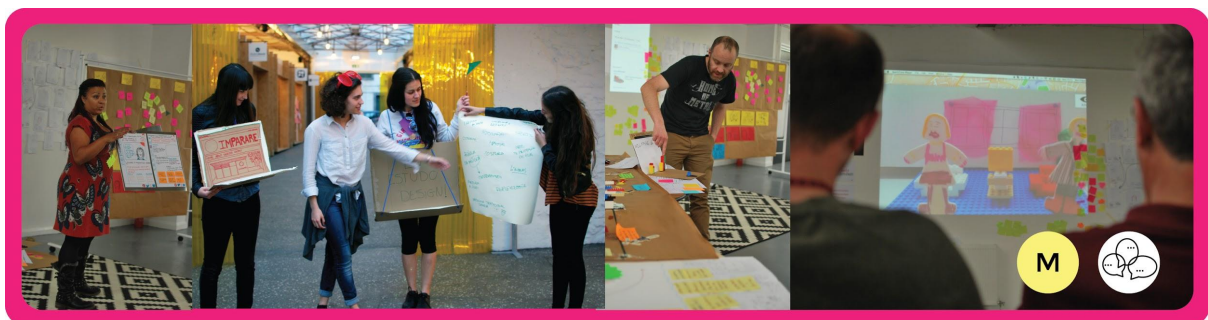

Figure 15. Final group presentations

The Jammers were required to apply their communication skills to produce short videos, photos of working prototypes and explanation of potential implementation of their group's design solution for the *Final Presentation* (Figure 15). The *Final Presentation* allowed the Jammers to celebrate their achievements in PDJs with the rest of the World via online platforms and social media. A sense of common purpose and commitment inspired the participants, in going through the design process and arriving at the end with a complete solution to the real problem.

5.1.4 Developing Collaboration Skills

Work organisation within the group was essential. The sense of responsibility to get the work done 'for good' and 'for the team' was shown with a good facilitation, especially in the second part of the design process, when it was time to materialise the ideas into prototypes and then to finalise the design proposal. *The configuration of the physical space* was considered to support collaboration. A considered space encouraged collaboration - not just within each group, but also among the groups. Space must allow dynamism and fluidity (Figure 16).

During the early stages of the Jam, *Energizers* can enhance trust and empathy within the team, which is then supported through open communication and collaboration during the Ideation and Prototyping phases. *Techniques and Tools* (e.g. Nudge Cards, "Yes, and…" Brainstorming Cards, Personas, Customer Journey Maps, Business Model Canvas, Stakeholders Map) that motivated participants to collaborate with others — not just within the team, but as an entire group of Jammers — could be used during the Ideation and Prototyping phases. These may include giving feedback during the sharing sessions, various brainstorming techniques, and meeting online other Jammers from across the world collaborating to find solutions to the same common cause (Figure 17).

Figure 16. Space setting should allow Jammers to move around and observe what the other teams are doing..
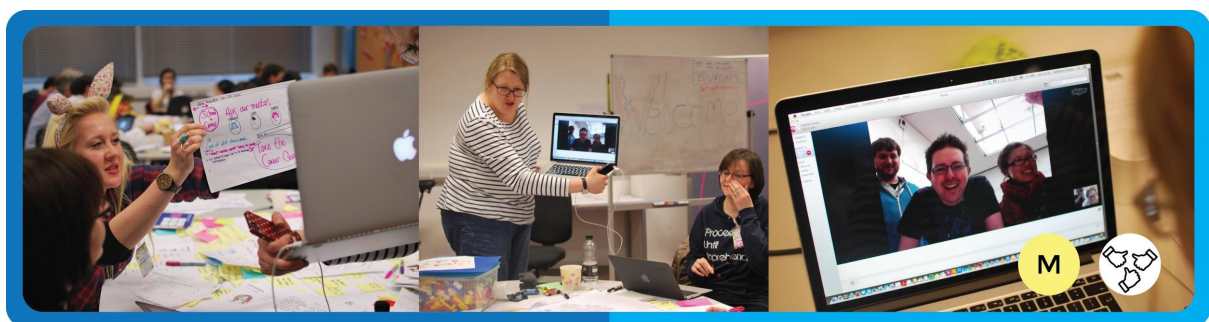
Figure 17. Sharing sessions with other Design Jams

The use of playful *Props* and gadgets allowed the participants to break socio-cultural and psychological barriers and smooth the conversations that otherwise might get quite serious and thus hinder collaboration. During the *Prototyping Phase* and *Finalising* of the project everyone in the group was allocated a task to complete. The shared responsibility had the potential to nurture participants' sense of collaboration and communication through its experiential, social and Jammers-activating nature.

Figure 18. Playful Jam prizes.

Funny Jam Prizes (Figure 18) for the best Jammers at the end of the event collaboratively recognised the spirit of the event and the shared experiences. *Prizes* with no material value were usually chosen to symbolise the spirit of PDJs. These characteristics may highlight the capacity of collaborating, staying positive, being playful and creative, as well as acting on sustainability. To close-up PDJ with humour and surprises allowed the participants to go home remembering the possibility of collaboration and having fun, especially when working hard to achieve better solutions to a complex problem.

5.2 Jammers' experience and perception of development of 4Cs

In the post-jam questionnaire, 95% (55/57) of the Jammers agreed that the jams helped develop their communication and collaboration skills, and 81% (46/57) agreed that jams helped develop their critical thinking and creativity skills. Particularly, Jammers felt that ''a playful environment" (40/57), "brainstorming" (35/57), "sharing sessions" (32/57), "prototyping" (28/57) and "jam schedule and deadlines" (25/57) enabled their teams to collaborate better and work towards a common goal. The three most useful activities that interview participants noted as assisting with the generation of their design solution
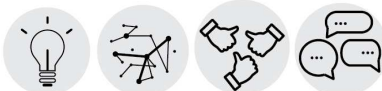
include: the sharing of knowledge and types of expertise within the team (19/27), prototyping and testing ideas (12/27) and meeting people in the streets and interviewing them (9/27). The large majority, 86% (49/57) of the Jammerss stated that jams were very playful. One commented that they "thoroughly enjoyed the talks and being forced to solve solutions under pressure. I love that" (POST-21). The potential of playfulness to support experiential learning was noted in observations and contributed to the group work experience. The inclusion of playful characteristics into the intensive learning process elicited positive responses from participants, like: "it was hard work, but still great fun and rewarding" (POST-07). Some participants had joined a Jam before, and returned because they "enjoyed the first one" (INTERVIEW-01) and they could "learn a lot and could … apply a lot in [their] study" (POST-23).
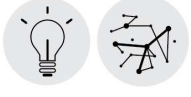
To interrogate and extract meaning from the observations and experiences, shared by Jammers, their comments and feedback was reviewed against collective creativity, critical thinking, communication and collaboration characteristics highlighted by Moiranoa et al. (2020), Harvey and Kou (2013), Bezanilla, Fernández-Nogueira, Poblete and Galindo-Domínguez (2019), Patel Pettitt and Wilson (2012) and Tiferes and Bisantz (2018). These are mapped to the positive experiences and perceptions of Jammers in Table 2.

Table 2: Mapping Jammer Positive Feedback Against Collective Creativity, Critical Thinking and Communication Criteria

Emerging criteria and associated 4Cs	Participants' Feedback and Reflections
4CC1: Different expertise, perspectives and knowledge celebrated in the team, and transdisciplinary knowledge sharing facilitated and supported. Relates to: *Creativity, Collaboration, Communication* 	"(The process) altered my perception of collaborative learning across different disciplines"(INTERVIEW-01). "It is important to have different disciplines within a team to reach a good outcome" (INTERVIEW-05). "We can see the different perspectives of people and different ideas. That helps a lot! And [we can] learn with each other" (INTERVIEW-07). "(It is) beneficial to experience and acknowledge different perspectives" (INTERVIEW-09). "[Though Jam] you get perceptions of other people with different backgrounds, which opens my mind (INTERVIEW-04). "Knowing new points of view of people we do not deal with on a day-to-day basis" (INTERVIEW-11).

4CC2: The activities should support social bonding and shared experiences Relates to: *Creativity, Communication*	"The undeniable fact that without collaboration, the project wouldn't have been that good" (INTERVIEW-03). "We were a group that shared many ideas. And we helped each other" (INTERVIEW-12). "We can listen and share experiences..." (INTERVIEW-15).
4CC3: A common language must be used and developed to allow for effective communication. Relates to: *Creativity, Collaboration, Communication*	"Being more open and not being afraid to share your ideas" (INTERVIEW-08). "Jam includes all key learning elements: first of all the listening, and then the ability to rework on an idea of other people" (INTERVIEW-14). "This is the first time I attended the Jam and worked in a team. They were all good listeners and involved me in activities in a nice way" (INTERVIEW-10). "This [Jam] taught me to listen to other people" (INTERVIEW-02).
4CC4: Activities must be focussed around a common goal or solving a challenge. Relates to: *Creativity, Collaboration, Communication*	"Everyone was on the same page" (INTERVIEW-04). "Thinking about how we could make the final presentation with the idea that we want to pass" (INTERVIEW-24). "I learn and work with other people who think differently [in the Jam], and this helps me come up with better and more innovative solutions" (INTERVIEW-06).
4CC5: The process must allow for acceptance and recognition of an individual within the team, but not at the cost of collaboration. Relates to: *Creativity, Collaboration*	"Our team [members] accept all different ideas and opinions, [we] always respect each other" (INTERVIEW-07). "It's always interesting, and we get to know new people in all Jams. We learn more from others and appreciate their works" (POST-13). "I learnt first of all the listening and then the ability to rework on an idea of other people" (INTERVIEW-14) "The capability of considering different perspectives on the problem and the solution" (INTERVIEW-23). "The ability to accept criticism" (INTERVIEW-20)
4CC6:The process must support open and unrestrictive exploration and various modes of representation to communicate findings. Relates to: *Creativity, Critical Thinking, Communication*	"Our group was open to criticism and new opinions" (INTERVIEW-06). "I've gained a lot [from collaboration]! New ideas, new approaches, and dialogue with those that you did not know... [It] challenges you to get out of your shell, test ideas, and work towards shared deadlines. Also, [it] gets you enthusiastic again and changes how you go forward with work and life" (INTERVIEW-02).

	"[T]he final result…is not just what we did for the [design] challenge, in the end, we are better, faster and more open-minded" (POST-06).
4CC7: Playful, well structured activities must support active learning. Relates to: *Creativity, Critical Thinking* 	"The Jam was a playful environment and approach to learning and working in groups, which we did not experience in the formal educational settings" (INTERVIEW-11). "The atmosphere I like the most: playful but very professional and focus on the theme" (INTERVIEW-19). "It was great to work on one theme - having fun, brainstorming. I enjoyed the energetic exercises, groups, prototyping and interviews to test prototypes, realise prototypes and attend contests to see the best project... designing in a fun and happy way. We can put our project to reality" (INTERVIEW-04). "To have so much fun, learning a lot, and meet wonderful people" (INTERVIEW-07). "I like Jam to learn and improve my skills in an unexpected but funny way" (INTERVIEW-07). "The playful atmosphere and the willingness of people to get involved and share ideas are the most unforgettable aspect of the Jam" (INTERVIEW-14).
4CC8: The process must encourage discussion and varying modes of communication. Relates to: *Creativity, Critical Thinking, Collaboration, Communication* 	"To do what you need to do, even if it is not your favourite thing. The important thing is to do it and learn from it, and of course, help the team to improve. Every task is important during the Jam" (INTERVIEW-17). "We can listen to and share experience and that leads us to a new idea" (INTERVIEW-03).
4CC9: Time constraints improve creative thinking. Relates to: *Creativity, Communication* 	"It was a great opportunity to work with a set time frame. I could not believe that in 48 hours all the groups would be able to achieve all of these. It was also a challenge to do something differently. It felt great to prove to myself I can do it. Working in a team was fun and good because the project grew thanks to our joint effort" (POST-33). "I remembered the rush and the pressure of delivering something significant the most about the Jam" (INTERVIEW-03).
4CC10: Activities must happen in a supportive and resources environment. Relates to: *Creativity, Collaboration*	"Jam provided great working environment, appetite for new ideas, general excitement" (INTERVIEW-01) "I applied the ability to work with others and accept criticism in my everyday life, after taking part in the Jam" (INTERVIEW-20).

4CC11: Facilitation and support must encourage engagement and mediate the conflict. Relates to: *Creativity, Collaboration* 	"Brainstorming, production of prototypes, and listening to the ideas of others were noted as key in 'growing the project'" (INTERVIEW-19). "We can think differently, and it's ok" (INTERVIEW-24). "Facilitators' support and suggestions allow my team to come up with a solution" (INTERVIEW-03). "It was very useful to speak to facilitators and they suggested how to proceed" (INTERVIEW-02).
4CC12: The influence of technology must be managed to ensure it supports discussion and problem exploration; not hinders it. Relates to: *Creativity, Collaboration* 	"Publishing solutions on social media and being part of a global event enabled better collaboration within our team. It is great to see what others all over the world are doing for the same design challenge" (INTERVIEW-24). "It feels great to be part of a global movement through social media" (INTERVIEW-10).
4CC13: The process must allow for 'free' generation of many ideas before they are evaluated and a final selection made. Relates to: *Creativity, Critical Thinking* 	"For me, it is to know different points of view. It really helps to see that there are always more solutions than you thought" (INTERVIEW-10). "Jam to me is to "show don't tell" (INTERVIEW-09). "I remember the most different ideas that have come up, the team and the fun of the Jam" (INTERVIEW-11). "Everything (that) comes from your own, and your team would be online, and (this) promote our engagement and encourage us to keep being creative, coming up with more new ideas" (INTERVIEW-10).

Six main teamwork challenges in Jams were identified by the Jammers (Table 3). Their comments were reviewed against the criteria of collective creativity, critical thinking, communication and collaboration established and applied in Table 2.

Table 3 Challenges of teamwork encountered in Jams

Challenges	**Participants' Feedback and Reflections**

4CC1: Different expertise, perspectives and knowledge celebrated in the team, and transdisciplinary knowledge sharing facilitated and supported. Relates to: *Creativity, Collaboration, Communication*	**Teamwork challenge 1: Participants' skills and knowledge must be communicated before team formation** "If I can improve the Jam experience, I would probably outline the participants' skills and knowledge to form groups with many [different] talents" (POST-25). **Teamwork challenge 2: Transdisciplinarity must be encouraged.** "[Including] more people and [people] from different areas is a must" (POST-08). "Try to invite participants from diverse disciplines, not only designers" (POST-23).
4CC9: Time constraints improve creative thinking. Relates to: *Creativity, Communication*	**Teamwork challenge 3: Time constraints may hinder relationship development and prototype finalisation.** "More time! Extend it to a full weekend. It is really worth it" (POST-19). "A proposal for the Jam could be that we spend three days on the project" (POST-23). "Jam projects need more time so that the teams can produce high quality products [concepts]" (POST-30). "We need more time to know each other from other groups" (POST-11).
4CC10: Activities must happen in a supportive and resources environment. Relates to: *Creativity, Collaboration*	**Teamwork challenge 4: Demand for specialised design knowledge supported.** "More holistic thinking approaches and design thinking approaches would be helpful" (INTERVIEW-11). "I want to learn more about design - its process, tools and knowledge" (INTERVIEW-26).
4CC11: Facilitation and support must encourage engagement and mediate the conflict. Relates to: *Creativity, Collaboration*	**Teamwork challenge 5: Organisation and management of teams required additional guidance.** "[A] better organisation of the groups would be useful" (POST-11). "Advice may be offered on how the role in the team could be set at the beginning: someone [should be] in charge of coordinating the team, someone of interviewing people, someone of visualising things and concepts, someone of building stuff, and, the social media to be part of a global movement/event (INTERVIEW-07).
4CC12: The influence of technology must be managed to ensure it supports discussion and problem exploration; not hinders it. Relates to: *Creativity, Collaboration*	**Teamwork challenge 6: Technology must be used to support greater discussions and sharing.** "It would be better to have skype connections to other jams" (POST-28). "Would it be possible to live stream different Design Jams and presentations, so people asked us questions and interacted with each other?" (POST-13)

Jammers described three personal factors that might influence engagement in Jams: language, personality factors and past Jam experiences (Table 4). Jammers who tend to be extroverted and sociable and have more Jam experience in the past might feel more engaged than those who tend to have language barriers and be introverted and very sensitive to conflict and competition.

Table 4 personal factors influencing jamming experience

Personal Factors	Participants' Feedback and Reflections
Past Jam experiences	"It's getting easier every Jam. Jam is almost like a prerequisite for me to enjoy collaborating with others " (INTERVIEW-03).
Personality related	"Working in teams is easy for me. It's part of my personality…" (INTERVIEW-14) **Socially oriented: eager to meet new people, comfortable in groups, and easy to talk to** "I like to talk to different people, so the jam was a nice opportunity" (INTERVIEW-17). "I love sharing ideas and meeting new people" (INTERVIEW-27). "I like working with others, because I enjoy hearing others' opinions" (INTERVIEW-20). **Introverted: not comfortable talking to a group of strangers** "I am a little embarrassed in large groups, and it was not easy to show people the design process, or accept ideas, which could be improved" (INTERVIEW-11). **Sensitive to conflict and competition** "Though I appreciate the purpose of the competition element of this jam - for me, I prefer a non-competitive Jam" (POST-15).
Language barriers	"I don't speak English very well so I could not express my ideas to the others very well" (INTERVIEW-19). "I really enjoyed it, but I couldn't help feeling a little shy at times, especially by speaking a different language" (INTERVIEW-02).

6. Discussion

From participants' feedback and observation, it was possible to identify whether the team development, motivation and characteristics of play embedded within PDJs present opportunities to develop the 4C's.

6.1 Creativity and Collaboration

All the Jammers indicated that teamwork skills, such as active listening and being open-minded, developed throughout the process of collaborating in their groups. Attending a Jam changed participants' attitudes toward learning, design and creative collaboration. Findings indicate that participants found teamwork easier after participating in a Jam and that they found themselves being more patient and willing to listen to others. These findings speak to Qing's (2011: p.37) 'authentic communication' which is developed through teamwork and contributes to empathetic collaboration. When one is open to multiple perspectives, it is possible to be more creative and explore more diverse, innovative solutions (Harvey & Kou, 2013). The Design Jam process highlighted the results a team could achieve within a limited timeframe, which exceeded the ability of a student as an individual.

Fundamental to the development of collaborative working skills is the interdependence that Design Jam activities require 'working in a group creates interdependency, as each member has a role to play and a job to do, and they cannot be egotistical or selfish, or the whole project will suffer. One person cannot dominate; everyone must play and experience together. Trust is necessary among the members of the group' (Piirto, 2011: p.35).

The concept of trust can further be explored through shared mental models. Salas, Sims and Burke (2005: p.565) succinctly describe shared mental models as a shared understanding reached when individuals in a group work collaboratively and can "coordinate by anticipating and predicting each other's needs through common understandings of the environment and expectations of performance". During a Design Jam, the ability to create and experience a shared mental model as a group is heightened through the sense of urgency created by a short fixed period of a Jam (traditionally 48 hours) and the immersive collaboration that a Jam encourages.

These transformative moments correlate with Rice's (2009) reflection that learning is not simply a cognitive process, but an effective process as well. The learning process required a fundamental change in Jammers' preconception of collaborative creative projects that POST-07 described as 'rewarding'. However, a few Jammers reported feeling "shy" (INTERVIEW-02) and challenged (e.g. POST-33; INTERVIEW-02), since they had to "get out of their shell" (INTERVIEW-02). These reflect the emotional responses associated with transformative learning (Meyer & Land, 2006). Creativity brings together critical thinking skills (another 21st-century skill), motivation and expertise (Howard et al., 2015). Motivation is crucial if one wants to be creative 'the main cause for creativity is that the creative person wants to be creative, in whatever domain he or she is working – whether it be woodworking in the basement, dancing, acting, drawing, singing, doing science, mathematics, inventing, being an entrepreneur, being an athlete, cooking, sewing, building, designing. People who are creative must have the motivation' (Piirto, 2011: p.7).

From a group perspective, relational conflict and task conflict will also impact creativity. Relational conflict may lead to the greater novelty of ideas due to the simulation of divergent thinking and task conflict, and the resulting convergent thinking may contribute to identifying the more useful and appropriate solution (Yong, 2014).

When collaborating within a group during a Jam, participants experience 'productive learning', which is critical for the development of creativity (Conneely et al., 2013). Through the collaborative process, the group could engage with creative thinking and arrive at "..better and more innovative solutions" (INTERVIEW-06). During productive learning, participants focussed on exploring challenges and finding solutions through a collaborative process, the process of creatively exploring the design challenge and identifying solutions can be fostered by role-playing. 'Similarly to the benefits role playing - allowing the development of communication skills - the activity may enhance creativity by providing participants with a method to gain empathy and engage their imagination' (Vyas et al., 2013: p.434). Facilitators should support the group members in understanding each other, finding a compromise, and making decisions when they are not able to do it on their own. From participants' comments, the impact of supportive facilitation can help Jammers move through the process and guide teams towards suitable solutions. Findings did, however, reveal that greater attention could be given to

the creative facilitation of group interaction during the event, as well as during the early stages of team forming. The participants' comments highlight the need for support and guidance during the formation of teams and while individuals build initial relationships. Facilitation must support the ability of a team to learn together and provide an opportunity to develop group maintenance skills. Without this, the creative experience runs the risk of contributing to 'mis-education', during which a team is expected to complete a challenge without the skills to successfully work together (Phipps, 2009). In this way, the facilitator may reduce the chance of conflict within the team and show the Jammers how maintaining a positive and proactive approach through the design process is possible.

Jammers acknowledged the importance of collaboration after attending a PDJ. Creative collaboration is not an easy task for some participants, who may experience difficulty with teamwork and compromise. The group activities prevalent in the Jam supported the development of creative collaboration skills. Jammers noted that they had developed the ability to "accept criticism" (INTERVIEW-20) and another indicated that they could see the benefit from "different perspectives of people" (INTERVIEW-07). These comments support the development of creative collaborative skills within the group, and often higher quality, more creative output (e.g. INTERVIEW-03; INTERVIEW-06).

Collaborating as a team is fundamental to the PDJ process. Through role play and other activities, a relational communication style develops that can affect creativity. Relational group contexts and the emerging communication style may be 'inherently appealing but also productive' (Barker et al., 2000: p.492). One does, however, need to acknowledge the challenges and stresses that such a relational context may bring. Relational conflict may have a negative impact on communication and creativity, whereas task conflict can have a positive impact on a group's creativity (Yong, 2014).

6.2 Critical Thinking Skills and Communication

Design Jams can be described as fast-paced - requiring a small group to move through the design process within 48-hours. The time constraint can add an element of stress, which could impact communication and the level of individual critical engagement. To mediate this, and to provide an environment that develops critical thinking, the Design Jam experience is carefully planned with a focus on practical activities. Including

practical activities, the process should foster positive behaviour through panning that promotes this (Banzilla et al., 2019).

When Jammers discuss ideas during a Jam, they not only engage with deep individual reasoning to evaluate ideas, they engage in rigorous group discussions and negotiation, which allows for the exploration of multiple viewpoints and potentially individual growth. From a group perspective, critical thinking helps Jammers 'deal with complex and changing environments while coordinating a diverse set of goals, roles, and cognitive abilities.' (Kayes, 2006: p.615). This concept was noted by participants:

> "[T]he final result…is not just what we did for the [design] challenge, in the end, we are better, faster and more open-minded" (POST-06).

Critical thinking, collaboration and communication skills are closely linked. Many participants considered sharing ideas 'a clear and effective communication' and 'a good capacity of cooperating to execute any agreed and organised activity' as enablers for collaboration, which reflects two of Blomqvist and Levy's (2006) collaboration capabilities, namely communication and commitment. Collaborating in small groups during activity (such as a Design Jam) can develop critical thinking skills as the process fosters 'discussion, clarification, ideas, and evaluation of other people's ideas' (Susantini et al., 2018: p.2). Problem-solving, and making decisions to support this, are fundamental to the development of critical thinking and difficult to separate from one another (Banzilla et al., 2019). Design Jams - as a process - further support the development of critical thinking as motivation, which is considered a necessary precondition for developing these skills (Lai, 2011).

During a Design Jam, communication goes beyond mere verbal skills to include gesture, physical artefacts and drawings among others. Engaging with multiple communication channels during a Design Jam allows one to explore the expression of ideas, perceptions and concerns, among others, linked to real world challenges. Fundamental to the development of critical thinking is the selection of: 'direct activities: carried out in a real-life context, direct observation of a phenomenon, reflective thinking, service learning, diary/reports, and dialogue' (Banzilla et al., 2019: p.3). These concepts could be difficult to express with only verbal communication methods (Vyas et al., 2013). As

small groups experience a stressful period, the level of explicit communication may decrease (Salas et al., 2005). Being able to expand the forms of communication during a Jam, to include visual and physical artefacts, allows members of the group to communicate using channels they feel comfortable with during stressful encounters. Another form of communication groups can explore during a PDJ is role play. While designing new services or products, designers have to think about out-of-the-box ideas that may be difficult to articulate using verbal means.

> Methods such as role play help in dealing with all these issues in one package— that requires a combination of functionality, expression and communication... Through role playing, a performer's ability to map his/her actions to certain features or tasks of design could help in understanding the envisioned product (Vyas et al., 2013: p.434).

Role playing, as a method of critical engagement and communication, draws from concepts of play and allows participants to express themselves using verbal skills, gestures and props. The resulting activity may help communicate the concept.

7. Conclusion

The ability to collaborate, communicate and be both critical and creative thinkers is essential in the 21st century. These four characteristics are often referred to as the 4C's. Design Jams are collaborative, fast-paced experiences that facilitate learning as part of a team, within a supported and facilitated environment. As a team progresses through the process, Jammers engage with all 4C's as they work collaboratively towards a creative solution, which is grounded in team communication and critical decision-making. Play is an integral part of the Design Jam process as it motivates participants to engage, explore, experiment and question their preconceptions. One could state that Design Jam is inherently playful. The original contribution made by this paper is the mapping of Playful Design Jams (PDJ) to highlight the elements of play that is present during the three-phase experience and how the process supports the development of positive interdependence within team-based activities.

The study demonstrates that taking part in PDJs activates participants' creativity and critical thinking, while contributing to communication and collaborative teamwork skills. It is suggested that further empirical studies examine the extent and level of 4C's development that various PDJ activities can facilitate in the long run. Furthermore, a

study that explores how PDJ activities could be improved to accommodate individual differences in the 4C's development is warranted, and this should involve Jammers with different personality types as social aspects may influence one's ability to communicate and collaborate with others.

Findings from the study indicate that participants found the creative facilitation of the session beneficial and that it helped their overall progress and solution development. The principles and theory of creative facilitation were immensely helpful in resolving some of the conflict experienced during the PDJ. Examples of this included the facilitated activities that promote input from multiple individuals (rotational brainstorming) to playful activities meant to ease feelings of shyness and promote engagement. There were, however, moments noted by participants where a more structured facilitation strategy could have benefitted the group. These mainly refer to early stages of group forming and goal setting, as well as the management of group dynamics and progress throughout the PDJ. It is suggested that the use of different forms of creative facilitation, complemented with team management tools during a PDJ, and the impact of this on each of the 4C's is further investigated.

PDJ offers formal education systems, as well as informal training sectors, a creative facilitated method to explore complex real-world challenges in a supportive environment. The process, and resulting team interactions, allows participants to develop a range of key skills that are fundamental to modern professional practice.

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Appendix 1:

Collective Creativity, Critical Thinking, Collaboration and Communication Criteria

Emerging criteria and associated 4Cs	Reference to literature
4CC1: Different expertise, perspectives and knowledge celebrated in the team, and transdisciplinary knowledge sharing facilitated and supported. Relates to: *Creativity, Collaboration, Communication*	"…multiple areas of expertise or diverse pools of knowledge…" (Moiranoa et al., 2020: 4) "Heterogeneous knowledge often requires extra resources and integrating relevant support mechanisms" (Moiranoa et al., 2020: 7). Barrier(s) to collaboration include: "Different knowledge held by different partners without clarity"; "Reluctance of individuals to release, or even share, their own (tacit) knowledge"; "Poor choices in personnel mix in project team selection"; "National or cultural differences" (Patel et al., 2012: 22) "Overall, the research studies suggest that people's functions and responsibilities on a team are related to how much they speak, and what they speak about" (Tiferes & Bisantz, 2018: 150).
4CC2: The activities should support social bonding and shared experiences Relates to: *Creativity, Communication*	"...teams should cultivate and maintain both internal bonding and external bridging social relationships to be creative" (Moiranoa et al., 2020: 8). "…develop new ideas together -even in the future- when participants get to know each other and have shared discussions and experiences" (Moiranoa et al., 2020: 9). "…relationship conflict has a negative influence on creativity." (Moiranoa et al., 2020: 9) "Role-playing is another powerful "shared experience" technique" (Suri & Marsh, 1997: 461).

4CC3: A common language must be used/ developed to allow for effective communication. Relates to: *Creativity, Collaboration, Communication*	"…participants have to develop a common language to understand each other in terms of the desired innovation as well as regarding their cooperation processes (Ness & Søreide, 2014; Schulz et al., 2015)" (Moiranoa et al., 2020: 8). "The beneficial engagement across disciplines requires trust and effective communication" (Moiranoa et al., 2020: 9). Barrier(s) to collaboration include: "Poorer coordination, communication and trust" (Patel et al., 2012: 22)
4CC4: Activities must be focussed around a common goal or solving a challenge. Relates to: *Creativity, Collaboration, Communication*	Requires a "…joint efforts and a common focus on searching for solutions" (Moiranoa et al., 2020: 8). "…teaching creativity has almost zero impact if it is not immersed in problem-solving exercises" (Moiranoa et al., 2020: 6). Barrier(s) to collaboration include: "Lack of project goals definition" (Patel et al., 2012: 22). "Character- and scenario-building Character invention/development and scenario-building are techniques which enable a design team to establish a common focus." (Suri & Marsh, 1997: 461).
4CC5: The process must allow for acceptance and recognition of an individual within the team, but not at the cost of collaboration. Relates to: *Creativity, Collaboration*	"Thus, individual attributes such as openness, conscientiousness, self-acceptance, hostility, impulsivity, individual independence, unconventionality, risk-taking, personal wide range of interests, a "discovery" orientation and task intrinsic motivation are also correlated with collective creativity" (Moiranoa et al., 2020:8). "…needs for acceptance, recognition and identity in interdisciplinary creative processes… elements that may constitute a creative climate, including the degree of individual freedom…" (Moiranoa et al., 2020: 9). Barrier(s) to collaboration include: "No culture of collaboration; systems geared to individual work" (Patel et al., 2012: 22).
4CC6: The process must support open and unrestrictive exploration and various modes of representation to communicate findings. Relates to: *Creativity, Critical Thinking, Communication*	"…when inhibitory control is low and inhibition is weaker, participants are more likely to consider more distant information, which in turn often leads to greater creativity…" (Moiranoa et al., 2020: 9) "Halpern (2014) gives ideas of different activities for teachers to use in the classroom in order to improve critical thinking, giving importance to visual representations, such as concept maps… mapping can enhance critical thinking" (Bezanilla et al., 2019: 3) "Maruping and Magni (2014) showed that communication problems decreased with task uncertainty" (Tiferes & Bisantz, 2018: 151). "…visual evidence is a powerful medium to communicate ideas, and operates well as a common language between people who have difficulty with others' frames of reference" (Suri & Marsh, 1997: 462).
4CC7: Playful, well structured activities must support active learning. Relates to: *Creativity, Critical Thinking*	"Researchers tend to agree games as a methodology foster creativity in interdisciplinary collaboration, not only computer based games (Horne, 2013; Tan, 2017) but also board, tinkering and playful games (Parjanen & Hyypiä, 2019; Bevan et al., 2015; Schulz et al., 2015)…The importance of the order of tasks, the role of the warming up exercises, engagement of players, generating a

	good spirit, support of cross boundaries of different knowledge, and help to players from different backgrounds and perspectives to communicate and build common ground are highlighted as critical elements of playing games for creativity purposes" (Moiranoa et al., 2020: 6). "To develop critical thinking, education activities should be appropriate and based on the principles of active learning, which Fink (2003) classifies as follows: First, information and ideas based on the use of primary and secondary sources found in class, out of class or online; second, experience concerning the activities of doing, observing or simulations; and third, reflexive dialogue, which may include writing papers, portfolios or diaries" (Bezanilla et al., 2019: 3). "…in order to teach critical thinking, the positive behaviour that is expected for the student to promote this competency should be included in the teaching planning, as well as the number of activities necessary for that behaviour to take place" (Bezanilla et al., 2019: 2).
4CC8: The process must encourage discussion and varying modes of communication. Relates to: *Creativity, Critical Thinking, Collaboration, Communication* 	"…collective discussion helps to deal with unexpected problems that require creativity" (Moiranoa et al., 2020: 9). "Walker (2003) highlights the importance of questioning yourself and others, interaction in class and discussions… First, create educational environments that allow students to practice dialogue and participation so that the classroom may be converted into a research community" (Bezanilla et al., 2019: 3). "…the importance of the feedback or synchronous and asynchronous feedback to develop critical thinking, not only through face-to-face sessions but also through electronic means..." (Bezanilla et al., 2019: 3) Barrier(s) to collaboration include: "Poor communication and low levels of trust"; "Inability to see constraints faced by partners, or others' perspectives" (Patel et al., 2012: 22). "In general, team members seem to communicate more when communication was less demanding, as communication volume was higher when teams communicated via voice a.s opposed to text based systems" (Tiferes & Bisantz, 2018: 151). "It is much harder to offer useful input from a distance, or in a context where spontaneous discussion is difficult" (Suri & Marsh, 1997: 463).
4CC9: Time constraints improve creative thinking. Relates to: *Creativity, Communication* 	"time and time constraint have a notable influence on creative thinking" (Moiranoa et al., 2020: 9). "…increased time pressure was associated with a higher "anticipation ratio"... Xiao et al. (2003) found that task urgency affected interaction pattern (the frequency of who talks to who)" (Tiferes & Bisantz, 2018: 151).
4CC10: Activities must happen in an supportive and resources environment. Relates to: *Creativity, Collaboration*	"Without environmental support, such as encouragement, social support, autonomy, resources or opportunities to present novel ideas, creativity may never come to fruition (Wieth & Francis, 2018), on the contrary, it will act as a barrier (Hepp K. et al., 2015)" (Moiranoa et al., 2020: 9).

	"An inspiring atmosphere and a harmonious environment enhances the synergy of creativity…" (Moiranoa et al., 2020: 9) Barrier(s) to collaboration include: "No commitment of resources to collaborative working" (Patel et al., 2012: 22).
4CC11: Facilitation and support must encourage engagement and mediate the conflict. Relates to: *Creativity, Collaboration*	"…elements that may constitute a creative climate .. the quality of support towards new ideas, a clear and inspiring vision provided by supervisors, and creative encouragement" (Moiranoa et al., 2020: 9). Barrier(s) to collaboration include: "Lack of support through training, supervision etc."; "Allowing divisions to grow and conflicts to remain unresolved; avoidance of issues"; "Allowing knowledge not to be shared, or people to opt out of collaboration"; "Mismatch or conflicts in leadership styles, culture, performance measures and goals" (Patel et al., 2012: 22).
4CC12:The influence of technology must be managed to ensure it supports discussion and problem exploration; not hinders it. Relates to: *Creativity, Collaboration*	"On one hand, significant evidence regarding the positive role of technology on creativity as a tool for learning, promoting a bigger picture thinking, multiple perspective thinking and connective thinking to flourish problem-solving and creativity was found (Ambrose, 2017; Borge & Bröring, 2017; Tan, 2017). On the other hand, there is a strong argument against technology mediation to foster creativity" (Moiranoa et al., 2020: 9). Barrier(s) to collaboration include: "Collaboration which is technology availability push-led rather than user needs pull-led"; "Overly optimistic views on technology capabilities"; "Overly pessimistic views on technology capabilities"; "Reduced or no face-to-face time" (Patel et al., 2012: 22).
4CC13: The process must allow for 'free' generation of many ideas before they are evaluated and a final selection made. Relates to: *Creativity, Critical Thinking*	Pg 372: " In a context with less underlying variability, or in which opportunities for interpretation do not exist, an evaluation-centered process may inhibit creativity" (Harvey & Kou, 2013: 372). "Olivares, Saiz, and Rivas (2013) indicate that it is very difficult to separate two strategies that help the student to think in a critical way, namely, that of taking decisions and solving problems. They believe that solving a problem conveys that an election has to be made, and thus, this may help the student to learn how to be critical with their choice" (Bezanilla et al., 2019: 3).