Toward an effective approach to collaboration education: A taxonomy for game design

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***Abstract*—Collaborative video games provide a challenge to designers, who must account for not only the thoughts and actions of individuals, but also the events and interactions among players. However, such games are also an important potential tool for teaching and promoting collaboration, a concept crucial to academia, industry, and education. Before we can develop the necessary design principles to guide game design or the assessment tools to determine the impact of collaborative video games, we must first understand the concept of collaboration. Unfortunately, collaboration is ambiguous, and contradictory definitions exist throughout literature. To reconcile the research space and develop a concrete understanding of collaboration, we analyzed over 25 existing studies and surveys from a wide range of disciplines and with diverse target demographics. The resulting multilevel taxonomy has four main components: group quality, coordination, communication, and support, which in turn are split into subcomponents. Our taxonomy can be used by researchers to inform study design, by game creators to develop design principles, and by educators to guide collaboration assessment.**

Keywords*—computer aided instruction, electronic learning, collaboration

I. Introduction

Collaboration has been shown to have numerous advantages. Studies show that young girls perform better in a collaborative environment than in a competitive one, while boys perform equally well in both [1], [2]. When compared to a competitive classroom structure, a collaborative environment has many positive outcomes, including greater group productivity [3], [4], higher achievement [4], and increased self-esteem [5]. Collaborative play has been shown to increase collaborative behaviors [6], [7], such as sharing [8], and to decrease aggression [6]. In addition, collaborative game interventions have been shown to result in positive attitudes toward peers [9], improvements in assertive behavior [10], and better leadership skills [11].

With such benefits, one may wonder how best to introduce and promote collaboration in the classroom. Before we can explore collaborative video games as a potential avenue, there needs to be a deeper understanding of the concept. In academia, there is no agreed upon definition. Furthermore, the terms "collaboration", "cooperation", and "teamwork" are sometimes used interchangeably [6], [12], [13], while other times they are intentionally differentiated [14]–[24]. The popularity of each term depends largely on the area of study; computer science favors *collaboration*, most prominently in the areas of Computer Supported Collaborative Learning (CSCL) [12], [16], [17], [23] and Computer Supported Collaborative Work (CSCW) [15], while *cooperation* dominates the field of psychology [3], [6], [8], [25]–[27] and *teamwork* is featured in the industry [14], [28], [29] and military [21], [30] sectors.

Some researchers define collaboration by its behaviors and skills, which in turn are often defined themselves [14], [20], [31], while others define collaboration as an activity [22], [27], [32] or a context [3], [11], [26]. For the purposes of our work, we borrow from the definitions of Roschelle and Teasley [22] and Ryan and Wheeler [26] to define collaboration as

> The mutual engagement of participants, whose goals are interdependent and positively correlated, in a coordinated effort to complete a task

Although useful, such a concise definition does not convey the complex facets of collaboration. To reconcile the research space and develop an understanding granular enough to effectively guide game design, inform collaboration assessment, and direct future research, we developed a multilevel taxonomy based on an analysis of over 25 existing studies and surveys from a wide range of disciplines and with diverse target demographics. The taxonomy has four main components, each split into more precise subcomponents. The first component is group quality: aspects indirectly related to task completion, while the second is coordination, which includes group member organization and action synchronization through communication, the third component. The last component is support; group members should help each other with task completion, role execution, and concept understanding.

II. Related Work

Some researchers explore collaboration as a process [17], while others focus on particular aspects of collaboration, such as message sending [15], helping [6]–[8], [11], [26], [28], strategizing [16], shared cognition [22], [32], and atmosphere [27]. Researchers have explored collaboration in general as well, but oftentimes with a focus on a particular context, such as the classroom [3], [13], [23], [24], the military [19]–[21], [30], [33], [34], the aviation industry [18], the medical industry [14], [29], [31], and industry in general [35]. Our taxonomy spans all of these contexts and incorporates the aspects of collaboration mentioned above.

A subset of collaboration popular in psychology literature is prosocial behavior: "voluntary, intentional behavior that

results in benefits for another; the motive is unspecified and may be positive, negative, or both" [36]. Examples include comforting, sharing, and helping [37]. Like collaboration, prosocial behavior can be split into categories. Zahn-Waxler and Radke-Yarrow [38] categorize it into help, statements of sympathy, protection, physical comfort, sharing, and cooperation, while Brief and Motowidlo [39] focus on a workplace environment and identify context-specific categories including assisting co-workers with personal matters, complying with organizational values, policies, and regulations, and putting forth extra effort on the job.

III. Taxonomy

We analyzed over 25 existing studies and surveys from a wide range of disciplines (Figure 1) and with diverse target demographics. Due to the ambiguity and interchangeability of various terms similar to collaboration, we included papers and articles pertaining to collaboration, cooperation, and teamwork (Figure 1), as well as those on prosocial behavior, a subset of collaboration focused on help and support. Because of our emphasis on collaborative problem solving, we chose to omit research on other collaborative scenarios, such as collaborative learning, unless it had broader implications.

A. Group Quality

The first component in our taxonomy is *group quality*: group aspects indirectly related to task completion. Even if each group member is highly intelligent and capable of performing all necessary functions, if members feel isolated, lack motivation, or simply do not get along, then group performance can suffer. For example, when a conflict arises, ineffective conflict resolution can lead to a prolonged period of time dedicated to overcoming the dispute rather than completing the task. Because of its many facets, we split group quality into four subcomponents.

The first subcomponent is *atmosphere*, which can be viewed on different scales, including control or hostility during group interactions [25]. Atmosphere is based on many factors, such as positive relations among group members [3], [18], [30], ample encouragement of communication [18], and effective conflict resolution [18], [23], [35]. Atmosphere is also affected by the value members place on personal gains versus those of the group [27] and by the attitudes of group members toward group participation [25], group work [17], and the task [30].

Effort towards the development of a positive atmosphere [18] is an example of member *involvement*. Involvement can be thought of in a general sense [15], [18], [23]–[25], [34] or more specifically in relation to certain aspects of group work, such as in reviewing boundaries, guidelines, and roles [17]. It can take the form of involvement in group quality, such as the encouragement of others' involvement [18], [34], or in effective undertaking of the task, such as through strong focus on the group task [29], attention during group discussions [3], and interest in everyone's performance [13].

To uphold a positive atmosphere, it is sometimes necessary for someone with *leadership* skills [23], [34] to contribute during group work. There may be a designated leader, which occurs often in the commercial and military sectors, or group members may share the responsibility of performing leader

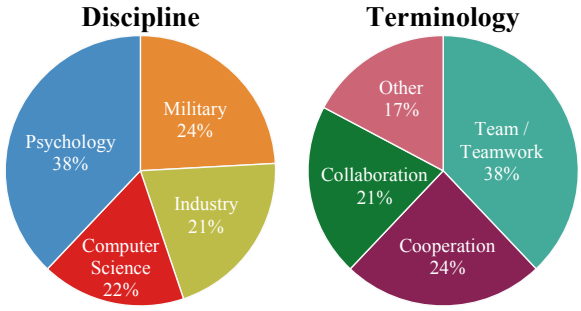

Fig. 1. Literature review distribution.

functions. Leadership skills include direction [14], [18], [19], [21], [30], discussion mediation [23], performance assessment [14], positive atmosphere facilitation [14], [18], and effective organization of individuals and tasks [14], [29], [30], all while exuding authority [31] and assertiveness [29], [31].

Another leadership skill is providing emotional care [30], often in the form of raising *team spirit* [3], [14], [18]. It can originate from positive physical contact [6], [7], [19] or words of motivation [19], [21], [23], encouragement [23], [35], and praise [19], [21]. We distinguish emotional support from support related to a task, the latter of which is its own component of collaboration.

B. Coordination

The next component in our taxonomy is *coordination*: the methods that groups use to organize group members and their actions. Without coordination, a team cannot effectively distribute sub-tasks to maximize group performance, nor is it trivial to respond to environmental changes.

One subcomponent of coordination is the *organization* of group members. Whilst the implied strengths and weaknesses of roles help facilitate quick and optimal task assignment, member roles also invoke an implied authority, which limits inter-member disputes. To remain effectively organized, group members should define [3], [24], [25] and fulfill [25] designated roles, even under duress [20].

After role designation, a group can begin to approach an impending task, taking into account the problem, possible solutions, and group member strengths and weaknesses. This *strategizing* includes how well group members communicate [17] and create strategies [3], [13], [14], [16]–[18], [25], [26], [31], [35], in addition to how well they understand [13], [17], [18], [34], select between [14], [18], [31], and execute [13], [16], [17], [34] those strategies. Other aspects of strategizing include decision making [20], prioritization [18], [29], [31], and resource management [14], [19], [26], [29], [31].

Often an initial effort is not enough; *adaptation* is needed to re-optimize organization [3], strategies [14], [18]–[20], [24], [33]–[35], and resource distribution [34] as circumstances change. To adjust accordingly, groups must anticipate [34], [35] or identify [14], [33], [34] the need for change and effectively implement it, possibly by creating an innovative approach [35].

To help identify when adaptation is necessary, groups can use *monitoring*, which involves re-evaluating a strategy [18],

[31] and supervising group functions and influences, such as standards compliance [17], [18], [31], boundaries [17], roles [17], environmental changes [35], and adherence to the chosen strategy [13], [17]. Monitoring also includes seeking feedback [30] and keeping track of the big picture [17], [33], as well as overseeing [19], [30], [35] and reflecting on [20] the actions of group members [7] and reviewing past decisions [29] to provide feedback on performance [19], [20], [23], [29], [30].

Through strategizing, adaptation, and general interaction, group members form a shared mental model [13], [23], also known as a joint problem space [22], [32], of the situation [24], [33], task [17], [22], [32], goals [17], [22], [32], available actions [22], [32], and the relations between these notions [22], [32]. This *shared cognition* allows the group to function as a single entity. Through information exchange [14], [29], [31], [35], sometimes via the articulation of expectations [34], group members formulate an understanding of others' opinions [3], values [3], aptitudes [3], and attitudes toward one's role in the group [3]. Monitoring shared cognition involves ensuring no discrepancy between individual mental models and making adjustments if necessary [32], [33].

C. Communication

Coordination is usually achieved through effective *communication*, often via speech or written message. While this component does not encompass task-specific content, such as strategies, it does include considerations before message sending, apt response to message reception, and the appropriateness of message content. Without adequate communication skills, group members cannot articulate thoughts and opinions, which inhibits the ability to form a shared mental model and prevents the creation of an optimal strategy based on the informed opinions of group members.

Sending a quality message is non-trivial. Messages should be original [15], precise [17], accurate [20], complete [20], timely [17], [20], and with information in the correct order [19]. A message sender should consider conformity to the current discussion [15], terminology [19], [30], content sensitivity [18], aptness of dissemination [20], distribution method [30], recipients [20], and the differences in delivering it verbally (with loud and distinct speech [19]) vs. non-verbally [18].

After a message is sent, the sender should confirm it reaches its destination [14]. In return, when *receiving* a message, the recipient should pay attention [3], confirm receipt [30], verify no information was lost in transfer [19], and ask for clarification [19], [20], [23], [30], justification [23], or elaboration [23] if necessary. A discussion concerning the contents of the message may ensue afterward [20].

D. Support

The final component of collaboration is *support*: group members helping each other complete a task [3], [11], [17]–[19], [21], [28], [30], [31], [34], [35], satisfy a role [28], [34], [35], take on a responsibility [34] or understand a concept [23]. The quality of support is based on many factors, including an individual's willingness [8], [13], time [35], resources [35], and ability [13], [30], [35] to help, as well as a person's understanding of the tasks assigned to fellow group members [13]. Without support, group members cannot build off of each other's experiences and knowledge, meaning time is wasted learning without a teacher or mentor and re-developing solutions for obstacles overcome in the past.

Help must first undergo an *initialization* during which a group member recognizes [28] and offers help [6], [7], [18], [26] or someone asks for help [11], [13], [19], [19], [26], [35] and a peer agrees to provide it [6], [7], [26], [28]. In either case, it is important to retain a positive atmosphere, otherwise derogative comments and condescending reprimands discourage help requests.

After initialization, help itself can commence. Some researchers view help as a broad concept [17], but we split such actions into two varieties: direct and indirect. *Direct help* involves explicit aid through the supply of instructions [6], [7], [35], an explanation of what to do next [19], or the partial [6], [28] or total [6], [19], [28], [35] completion of a task assigned to another group member. Unfortunately, with direct help, the person being helped forgoes the knowledge and experience often gained from personally overcoming a challenge.

A better alternative may be to supply *indirect help* through resource sharing [6]–[8], [11], [28], [35] or by providing guidance [30], [34], [35], education [29], structure [30], suggestions [19], [35], advise [35] or constructive feedback [35]. This type of help is especially advantageous in error correction, when a group member can provide guidance on error detection [21] or suggest reassessment to prompt someone to find her own mistake [19], [21]. When pointing out a mistake or potential mistake [35], a person should be nice [19] and avoid doing it verbally, which attracts more attention than gestures [19].

During *help reception*, a group member should not be afraid to ask if an error occurred [19], should try to understand why something is wrong [19], and should thank anyone that helps [19], [21]. Attention and courtesy are ways to show appreciation and respect, contributing to a positive atmosphere.

IV. Implications

Because of its diverse source material, our taxonomy is applicable to many research areas and subject demographics. Its multiple levels allow for varied scope, while its hierarchical structure lends to a deeper understanding of subcomponent relations. In addition, it can be combined with known methods of evaluation to explore topics such as:

- Strategy creation and retention, which would include measuring quality, complexity, and appropriateness.
- Participation, which would include measuring involvement, message sending, team spirit, leadership, and number of utterances.
- Communication, which would include measuring communication, voice volume, and how often an individual answers other people's questions.

The taxonomy can be used by researchers to aid in study design by providing a focused skill set for assessment, even outside of the educational game space. During game development, designers can use the taxonomy to develop principles that support a game's collaborative nature and learning objectives that pertain to collaboration. Even educators can use

the taxonomy to identify and evaluate students' collaborative skills. Whether exploring the effectiveness of collaborative software in the office or the implications of collaborative learning in the classroom, our taxonomy can help guide future academic research and collaborative game design.

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