What Kind of World Do You Want to Live In? Positive Interdependence and Collaborative Processes in the Tangible Tabletop Land-Use Planning Game Youtopia

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Abstract: Twenty pairs of 5th grade children used a tangible tabletop sustainability game to create a world they would want to live in to share with the rest of the class. Half of the pairs were assigned particular roles with associated game controls (positive interdependence condition) while the other half were not (control condition). Results showed that pairs in the assigned roles/controls condition gave more in-depth explanations to their partners about what they wanted to do in the game, but did not negotiate with each other more frequently than control pairs. They also had fewer but longer instances of jointly resolved conflict. Contrary to some previous findings, all pairs in both conditions were found to work together (rather than in parallel / competitively) the entire time. The general finding is a somewhat limited, but consistent, positive effect of the assigned roles/tools manipulation on collaborative processes.

Keywords: Tangible systems, emergent dialogue, student roles, positive interdependence

Collaborative learning with interactive tabletops

Interactive tabletops are horizontally oriented digital surfaces that allow for direct physical interaction by users (Higgins et al., 2011). They have been highlighted as a technology particularly suited to supporting collaborative learning interactions as they are designed for more than one user, hands-on activities and multiple modes of communication (Dillenbourg & Evans, 2011). Specifically, they have been suggested to have particular affordances for facilitating joint attention and creating a shared transaction space for reference, negotiation, and action (Fernaeus & Tholander, 2006). Of course, opportunities for collaboration aren't always taken up by learners and other interaction patterns are possible such as domination by one child, independent parallel play, and competition (Marshall et al., 2009). Thus two central challenges in designing interactive tabletop applications for collaborative learning are finding ways to distribute control across a group and getting group members to engage with each other constructively (Higgins et al., 2011). One way to do this is by structuring positive interdependence into the activity design in technological and/or social ways (Dillenbourg & Evans, 2011). There are many CSCL scripts designed towards this end such as assignment of roles, distribution of information, or designation of tools to particular learners (Järvelä et al., 2004). The aim of creating positive interdependence is to encourage learners to work together (as opposed to independently, in parallel or divide-and-conquer mode), animate greater negotiation of decisions taken as part of the collaborative task, and foster the resolution of conflict jointly (rather than via unilateral action).

Positive interdependence and tangibles

An important characteristic of interactive tabletops that distinguishes them from many CSCL technologies is that they support co-located face-to-face synchronous collaboration (Dillenbourg & Evans, 2011). This allows for the integration of tangibles: digitally augmented physical objects that are recognized by and can affect / be affected by the tabletop system (Ullmer & Ishii, 2000). Tangibles offer particular affordances for creating positive interdependence as they allow for the physical embodiment of distributed control, tapping into social norms around object ownership and use (Speelpenning et al, 2011). Such technological interdependence can be employed on its own (e.g. using colors to designate tangram pieces for use by different group members; Dillenbourg & Evans, 2011) or in concert with social interdependence (i.e. tools are distributed in alignment with particular duties). The latter strategy is particularly attractive as a way to address the challenge of getting learners to actually adopt the distinct rights and responsibilities of the role they are assigned (Wise et al., 2012).

Previously we have described the design of Youtopia, a tangible and multi-touch tabletop activity about sustainable land-use planning (Antle et al., 2013). The game's design includes co-dependent access points where more than one input action must be taken sequentially in order to create a successful system response. This aim of this design strategy is to encourage exploration of the game space and the content relations about sustainable land-use embedded within it (Fan et al., 2014). In this work we investigate whether adding scripted roles with associated tools (social/technological interdependence) to the existing contingencies of tangible use (described below) affects the quantity and quality of collaboration processes. Notably, we do so in a study of children in an authentic school environment, addressing recent critiques that interactive tabletop research has been overly focused on tool development rather than in-vivo studies of collaborative learning (Higgins et al., 2011).

The Youtopia system

Youtopia is a hybrid tangible and multi-touch tabletop application about sustainable land-use planning. The activity was designed for pairs of elementary school children and aligned with the learning objectives for environmental and sustainability topics outlined in the B.C. Prescribed Learning Outcomes (Grade 5) and the U.S. National Science Education Standards (K-4). Using Youtopia, children have the opportunity to design their own world, exploring how different land-use decisions affect the amount of food, housing and energy provided to the population; and the impact these decisions have on the level of pollution in the environment. Following the principles of Emergent Design (Antle et al., 2014), our interaction goals were for children to explore the relationships between different land-use decisions, see their effects on the world, discuss the inherent tradeoffs with their partner, and through this make informed decisions to create a world they would want to live in. To foster the need to explore relationships and discuss trade-offs, the activity was calibrated to make it difficult/impossible (depending on the game mode) to satisfy human needs without some pollution.

Children begin with one of four digital maps of an undeveloped valley with different types of terrain: mountains, grasslands, forest and a river. The primary method of interaction with the tabletop is through two kinds of physical stamps that children use to designate different land-use types on the map (see Figure 1a): natural resource stamps (indicated with a tree icon); and human development stamps (indicated with a wrench icon) [see Table 1]. Each stamp also has a picture and a label describing the specific land-use type, and color is used to indicate land-uses that relate to the same human need (see Figure 1b). In this way children are supported in seeing two kinds of relationships between land-uses: first, which ones are used to meet the same human need (e.g. energy, food, housing – coded by color); and second, the interrelations of natural resources and human developments within a color category (e.g. a coal mine (tree) is a direct use of a natural resource, while a coal plant (wrench) is human development based on that resource; both are required to produce coal-based energy).

(a) (b)

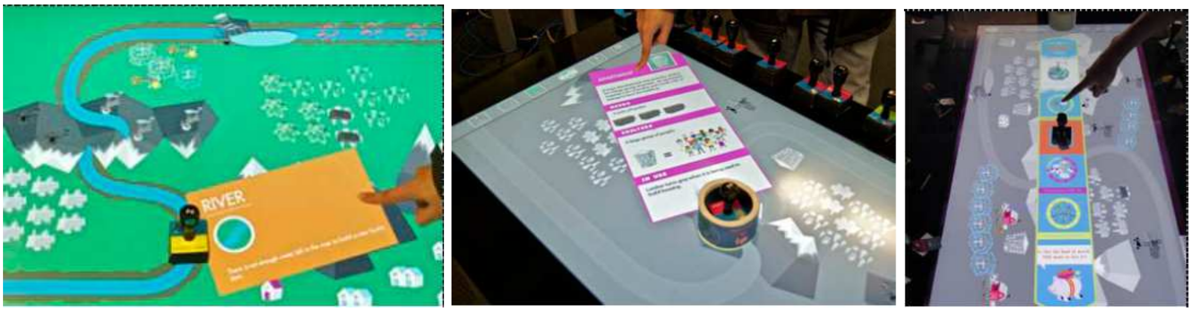
Figure 1. (a) Using a stamp to designate a land-use (b) Colored tags identify groups of related stamps

Land-use types have predefined relationships to each other and to the terrain designed to reflect real world relations (see Table 1). For example, a farm can only be built on grasslands (not on a mountain) and requires irrigation connecting it to a water source (the river). Thus different inputs to the system are codependent: while each stamp is used individually, to successfully build anything requires two or more stamps placed in sequence. Children are able to discover the underlying logic of the system in several ways. If a child stamps a 'legal' land-use (in an allowed location; required resources are met), a digital version of the land-use picture on the stamp appears on the map. If a child stamps a land-use that doesn't meet these conditions, an explanation tab focused on describing land-use relationships (e.g. "Houses need lumber from the forest to be constructed") will appear and can be enlarged and rotated (Figure 2a). When a land-use is successfully placed, any resources it requires are greyed out so that children can see the effects of using land in this way and what resources are still available. Children can also learn about how each of the land-use types work using the info ring, an open circular tangible that can be placed on the table with stamps inside it (Figure 2b). When a stamp is placed in the info ring the system displays information about what resources the land-use requires and produces as well as geographic constraints on its usage. Finally, the impact stamp provides a way for children to assess the state of their world in terms of what proportion of the population has shelter, food and energy, as well as how polluted the world is (see Figure 2c). In keeping with the principles of Emergent Design, no judgment of the world state as good or bad is provided; however an image of a pig asks "Is this a world you want to live in?" with the goal of eliciting a discussion of values. Use of the info ring or impact tool freezes the interaction in the system to give children time for reflection (Antle & Wise, 2013). The system was implemented on a Microsoft PixelSense digital tabletop. Usability testing to ensure basic standards were met was conducted prior to running the study. A short video of functionality is available at www.youtube.com/watch?v=o7CsEICA8nQ.

Table 1: Types of Youtopia land-use stamps

Area of Human Need	Natural Resource Stamps	Human Development Stamps
Food (green labels)	Garden, Farm ←	Irrigation
Shelter (pink labels)	Harvest Lumber →	Houses, Town Houses, Apartments
Energy (yellow labels)*	Coal Mine →	Coal Plant Hydro Plant
Environment (orange labels)**	Forest, River & Mountain Reserves	

Notes: Arrows indicate which land-uses create resources required for other land-uses. *Energy land-uses *increase* the pollution in the world to different extents. **Environment land-uses *reduce* the pollution in the world to different extents



(a) (b) (c)

Figure 2. Youtopia (a) error tabs (b) info ring (c) impact tool

Research questions

As described above, in this study we sought to investigate whether assigning children roles and distributing associated controls across the TUI learning environment affected the quantity and quality of children's collaborative processes, hypothesizing that it would promote more collaborative behaviors than unscripted use of the system. In future work we will also examine effects on the outcomes of the collaborative activity. *Research Question: Does assigning children interdependent roles/ tools in Youtopia lead to increases in (a) working together? (b) talking in-depth about the sustainability domain? (c) resolving conflicts jointly rather than unilaterally?*

Methods

Research design

The study employed a post-test only experimental design. The independent variable was whether or not pairs using Youtopia were assigned particular roles with associated controls to use while they engaged in the activity. Because collaborative activity was our focus (and thus we expect learning partners to influence each other rather than be independent) pairs of children were taken as the unit of analysis. Dependent variables included measures of children's collaborative processes coded from video data and reported by children in a post-activity survey.

Participants and learning environment

Forty 5th grade children (ages 10-11, 18 boys / 22 girls) from two classrooms participated in the study in pairs (N=20). Pairs were assigned by the teachers to match children based on three criteria: one, children work well together; two, children of high ability are distributed across pairs; and three, pairs do not have one individual who is verbally dominant over the other. In addition, teachers were asked to make mixed-gender pairings to avoid differences in boy-boy and girl-girl pairs; however the class gender ratio necessitated was one girl-girl pair in each class. Pairs were randomly assigned (by the researchers) to the roles or no-roles condition, with the restriction of equal representation in each condition across the two classes. Children were mostly regular users of technology, though there were some exceptions. Due to the culture of the classrooms (and overall school) all children had extensive prior experience collaborating. In addition all children had participated in a class unit on sustainability issues four months earlier, thus prior knowledge on the topic was generally high. The use of Youtopia was introduced as a review of the sustainability unit in which children would have the opportunity to engage in the land-use planning activity and then share and explain their final world with the class at the end.

Data collection

Video
Two installations of Youtopia (tabletop system, tangible objects, and associated software) were set up in separate rooms apart from the regular classroom to create a distraction-free environment. Each room was equipped with a high-definition digital video camera capturing a landscape view of the children users (and an oblique view of the tabletop surface). Video of twenty sessions of approximately a half-hour each was collected.

Survey
At the end of their time using Youtopia, children completed a short survey that asked them for: demographic information (age and gender); the frequency with which they used certain technologies at home; and their self-reports of (a) the process of working with their partner; (b) what they learned from the Youtopia activity; and (c) the importance / difficulty of making land-use decisions to create a world they want to live in. Full text of questions is included in the results section. For each, children indicated on whether a statement was true/important/difficult on a five point scale ranging from "not at all" to "very."

Procedure
Three research team members administered each session of Youtopia; classroom teachers were not present. Pairs were told they would have up to 25 minutes to engage in the activity. The facilitator began by introducing the children to Youtopia and giving them a basic tutorial of system functionality. Children were then invited to use the Youtopia system to create a "world they would want to live in." Specifically they were told to work together to make housing, food, energy and nature reserves and that they could change and rebuild their world until they were happy with it. No instructions were given as to what the created world should look like. Children were also made aware that after all pairs had completed their Youtopia sessions, they would be asked to share a printed-out version of their final world map and impact display with the rest of their class.

In the roles condition, one child was assigned to be the "manager of natural resources" and given all the "tree" stamps associated with this role (lumber, garden, farm, coal mine, nature reserve, river reserve, mountain reserve); the other child was assigned to be the "manager of human development" and given the "wrench" stamps associated with this role (irrigation, house, townhouse, apartment, coal plant, hydro dam). Roles were assigned randomly to children by the researchers, balancing across gender in the overall sample. Tools not associated with a particular role (impact tool, information ring, eraser tool) were placed at the end of table between the children. In the no-roles condition the pair was simply given access to all of the stamps / tools placed at the end of the table equidistant between them and grouped by color related to particular human needs (see Figure 1b and Table 1). Youtopia activity sessions were spread across the course of a week.

Data coding
Video data was coded to index two aspects of children's collaborative processes: first, the degree and type of their in-depth talk about the sustainability domain; and second, the degree of conflict they had around the sustainability domain and how it was resolved. We had initially also planned to code a more general collaboration measure of "working together" (time in which both children worked on a common element of the task); however, since all pairs in the study were seen to work together all the time, this measure was discarded and working together was indexed simply by the total time the children engaged with Youtopia.

In-Depth Events were identified as periods of Youtopia use in which one or both children explained their thinking / reasoning related to decisions about what resources and developments to use in the activity. For example "Let's build houses, not apartments-they use less lumber so we can make more nature reserves" would be coded as In-Depth, but "I think we should have houses not trees" would not. Occasions in which only one child explained their thinking or reasoning were coded as *Solo In-Depth Events*, while episodes in which both children explained their thinking were coded as *Together In-Depth Events*.

Conflict Events were identified as periods of Youtopia use in which children expressed verbal and/or physical disagreement with the other's actions or utterances related to the sustainability domain. For example if one child started to stamp a Garden and the other said "No, let's make a Farm," or one child wordlessly grabbed another's stamp it would be coded as conflict. However, if one child presented options and the other decided, (e.g. “We could make a Garden or a Farm…” “Farm!”) it was not considered conflict. Each conflict event was coded as being *Resolved Unilaterally* (one child takes action without other’s consent), *Resolved Jointly* (agreement is reached before action is taken), or *Not Resolved* (the conflict was abandoned).

Three researchers were involved in coding the video data, marking all In-Depth and Conflict Events of the types described above with both a start and end time. These were used to calculate variables for both the frequency (number of occurrences) and average duration of each kind of event. Because the presence or absence of assigned roles was apparent in the videos, coders were not blind to condition. Before proceeding with the actual coding, the three researchers first used a training video to practice and refine the indicators and examples for each category. For inter-rater reliability Cohen’s kappa was calculated based on the overlap of time segments coded as In-Depth or Conflict, permitting a 5 second tolerance at the start and end of events. Thirty percent (six) of the videos were double coded, three at the start of the analysis ($\kappa_{\text{In-Depth}} = .63$; $\kappa_{\text{Conflict}} = .81$), and three at the midpoint ($\kappa_{\text{In-Depth}} = .65$; $\kappa_{\text{Conflict}} = .92$). All differences in coding were reconciled.

Results

Youtopia gameplay sessions lasted between 14 and 30 min, with an average length of 23 min (SD=4.4). Examining the data set for outliers, there was one pair (roles condition) with no in-depth or conflict events of any kind throughout their entire session. Review of the video for this pair revealed that they were notably quiet compared to all other pairs and appeared to be relatively disengaged from the task throughout the session. The data from this pair was thus removed from the analysis. For the remaining 19 pairs, the data below is presented first descriptively across the entire sample and then compared across conditions. Due to the small sample size and a clearly identified hypothesized direction of effects, one-tailed tests were used.

Working together

All pairs reported high levels of working together (this was also indicated by initial viewing of the videos that led to the elimination of the working together coding); no differences were seen between the two conditions (see Table 2). The amount of time spent working together (indexed by duration of Youtopia use) was 3 min longer on average for pairs in the roles condition; however the difference failed to reach significance (Table 2).

Table 2. Mean and standard deviation of working together variables by condition

	No-Roles (N=10)	Roles (N=9)	t	p††
“I worked a lot with my partner while I was doing the activity” †	4.35 (0.41)	4.28 (0.36)	-0.40	(.336)
“I worked mostly on my own while I was doing the activity” †	1.48 (0.45)	1.56 (0.52)	0.36	(.361)
Duration of Youtopia use (min)	21.85 (4.55)	24.99 (3.43)	1.69	.055

† The survey scale ran 1 to 5, with a higher number indicating a greater level of agreement with the statement
†† p values given are for one-tailed tests, parentheses indicate if the difference was not in the predicted direction

Talking in-depth about sustainability

Overall, pairs reported moderate levels of talking with their partner about the kind of world they wanted to live in and the degree to which they knew the kind of world that their partner wanted to live in after engaging with Youtopia (see Table 3). Counter to expectations, pairs in the no-roles condition reported somewhat higher levels of knowing the kind of world that their partner wanted to live in by the end of the activity; however even if this difference had been in the in the hypothesized direction, the effect would not have reached significance.

The total number of in-depth events per pair ranged between 2 and 19, with an average of 10 per session, accounting for ~5% of children’s total play time. Looking at patterns in individual versus collaborative in-depth talk across *all* pairs, on average there was a greater frequency of solo in-depth events (M=7.26, SD=3.90) than together in-depth events (M=2.95, SD=2.32) [$t_{18} = 6.31$, $p < .001$]. However, when they occurred, the together in-depth events had longer average durations (M=10.37 sec, SD=4.37) than the solo in-depth events (M=4.33 sec, SD=1.09) [$t_{16} = 5.39$, $p < .001$]. (Note that these are comparisons between event types across all pairs and thus different from the comparisons across condition shown in Table 3). Comparing role and no-role conditions, the number, but not length of solo in-depth events was greater for pairs in the roles condition. However, no differences were seen in the number or length of together in-depth events (see Table 3).

Table 3. Mean and standard deviation of talking about sustainability variables by condition

	No-Roles (N=10)	Roles (N=9)	T	p††
"My partner and I talked a lot about the kind of world we want to live in" †	3.58 (0.87)	3.39 (0.65)	-0.52	(.303)
"After playing the game together, I know what kind of world my partner wants to live in" †	4.20 (0.48)	3.81 (0.68)	-1.47	(.080)
***Solo In-Depth Events* - Frequency (number)**	**5.80 (2.86)**	**8.89 (4.40)**	**1.83**	**.042**
Solo In-Depth Events - Average Length (sec)	4.35 (1.05)	4.37 (1.12)	0.06	.957
Together In-Depth Events - Frequency (number)	2.60 (2.12)	3.33 (2.60)	0.68	.254
Together In-Depth Events - Average Length (sec)	10.89 (5.14) †††	9.78 (3.58) †††	0.51	.619

† The survey scale ran 1 to 5, with a higher number indicating a greater level of agreement with the statement
†† p values given are for one-tailed tests, parentheses indicate if the difference was not in the predicted direction
††† N in this cell was reduced by one, after removing a pair that did not have any In-Depth Together Events

Engaging in and resolving conflict

The data distribution for conflict was heavily skewed and kurtotic due to a substantial number of pairs without any conflict events; thus assumptions of normality were considered to be violated and non-parametric tests were used. The predicted increased frequency in unilaterally resolved conflict events for the no-roles condition was observed (see Table 4). However unexpectedly results showed the no-roles condition also had a greater frequency of jointly resolved conflict events; had our hypothesis for this variable been in the opposite direction, the difference would have been significant. There were few unresolved conflict events in either condition. As there was only one instance of unilaterally resolved conflict in all roles pairs, it was not possible to meaningfully compare duration. The same was true for unresolved conflict events. However jointly resolved conflict in the roles condition lasted significantly longer than jointly resolved conflict in the no-roles condition.

Table 4. Median frequency and duration of conflict event variables by condition

	No-Roles (N=10)		Roles (N=9)		Mann-Whitney p
	Median	Max	Median	Max	(one-tailed)
Unilaterally Resolved Conflict Events					
Frequency (number)	**0.5**	**4**	**0**	**1**	**.030**
Av Length (sec)	6.67†	12.5	4.4††	4.4	-
Jointly Resolved Conflict Events					
Frequency (number)	1	8	0	3	(.029)
Av length (sec)	**9.32†††**	**22.7**	**32.73††††**	**50.5**	**.031**
Unresolved Conflict Events					
Frequency (number)	0	1	0	2	.350
Average Length (sec)	12.61†††††	23.06	36.39††	36.39	-

Notes: Removing pairs that did not have any conflict events resolved in the indicated way, left the following cell sizes: †N=5, ††N=1, †††N=8, ††††N=4, †††††N=2, Mann-Whitney test was not run if combined N across cells <10

Discussion

Summary of results

Pairs of children reported generally high levels of working together and moderate levels of talking with their partner about the kind of world they want to live in, with no differences between conditions. Pairs in the roles condition spent a few minutes longer engaging with Youtopia and pairs in the non-roles condition described slightly higher levels of knowing the kind of world that their partner wanted to live in; however both differences failed to reach significance. Overall, events in which children talked in-depth about sustainability issues represented a small portion (5%) of their total session time, with solo in-depth talk occurring twice as frequently as together talk; however the together in-depth talk lasted twice as long. On average pairs assigned roles had one and a half times as many solo in-depth events than those who did not have roles. No differences were seen for the length of these events or the length or frequency of together in-depth events. Pairs without roles assigned had more unilaterally and jointly resolved conflict events than pairs who were assigned roles; however when pairs with roles engaged in jointly resolved conflict it lasted approximately three times as long.

Overall collaborative patterns

Before comparing the roles and no-roles conditions, it is useful to examine some of the overall collaborative patterns observed. First, pairs in both conditions worked together for the entire time of the activity. This is a positive finding amidst concerns about parallel independent play and competitive behaviors (Marshall et al., 2009). This may be a result of the game design, the classroom culture of collaboration set up by the teachers (Hakkarainen et al., 2002), the pairing of kids who worked well together by teachers or other factors. However, the proportion of the time working together that was identified as "in-depth" talk about the sustainability domain was only 5%. This may be in part because the bar for identification of in-depth events was set quite high, requiring children to talk about tradeoffs in the game and reasons for tradeoffs that involve environmental values (thus when this talk did occur it was very rich). In future work it may be necessary to relax these requirements to include a larger swath of relevant talk; however this also highlights an important point about CSCL analyses—that the "golden moments" in collaborative learning we aspire to (and see highlighted in the research) are often farther and fewer between than we would like to think. Interestingly, there is some indication in this study that the children themselves were aware of this difference, reporting high levels of working with their partner but only moderate levels of talking with their partner about the kind of world they want to live in. Overall there was a lack of conflict in this study with a substantial number of pairs having no conflict events at all. This may again be due to the classroom culture and/or pairing strategy used. Still, it is of potential concern since the negotiation and integration of differing perspectives is at the conceptual core of collaborative learning (e.g. Andriessen et al., 2003). Finally, solo in-depth events outnumbers together in-depth events two to one, suggesting an overall prevalence of explanation over negotiation. This is discussed further below.

The effects of assigning interdependent roles and tools

One effect of the interdependent roles and tool assignment was that pairs in the roles condition had more solo (but not together) in-depth events than pairs in the no-roles condition. This is an interesting and somewhat surprising finding since it was expected that the interdependent roles/tools would support children in discussing the sustainability tradeoffs and decisions they needed to make together. Instead, it seems that the role/tool assignment led the children to *explain* what they were doing to each other more often, but not necessarily *negotiate* it (note that an in-depth statement about a choice to be made in the environment that received a simply affirmative reply like "okay, good idea" would have been coded as a solo in-depth event because even though both children spoke, the second comment was not in-depth). In some sense then this is a positive finding since simply getting children to externalize their thinking and rationale may have benefits for reflective processes, collaboration, and learning (Price et al., 2003). However, we are curious as to why in-depth statements about sustainability and game choices did not consistently lead to substantive replies. One possibility is that children were too willing to agree with their partner (or unwilling to question them) in an effort to maintain harmony. Challenges in getting learners to disagree have been reported in CSCL environments previously (De Wever et al. 2008). However, that issue does not speak to why children didn't build on their partner's ideas. Again this may relate to the particular classroom culture of collaboration or perhaps that the game dynamics promoted taking (and seeing the effects of) decisions one step at a time, delaying the moment at which it is appropriate to build-upon a partner's idea until after the first decision has been enacted. We also note that this reflects a larger trend of solo over together in-depth events across the sample more broadly. Further investigation of the issue through examination of sequences of turn-taking is an interesting area for future research.

A second effect of the interdependent roles and tool assignment was that children without roles assigned had both more unilaterally resolved conflict events and jointly resolved conflict events. The greater number of unilaterally resolved conflicts was expected; in the absence of interdependent roles with associated tools, either child could make and enact a decision on the game board without gaining their partner's agreement. However the greater number of jointly resolved conflicts was not predicted; in fact it was expected that the positive interdependence of the roles condition would lead to more jointly resolved conflict. The cause of this effect remains unknown; it may be that in the absence of being assigned a particular perspective, each child was able to consider both sides of an issue of conflict and thus more easily detach themselves from their original view to come to a joint agreement. In the no roles condition both children could also undo or redo a game action at any time, making the cost of agreement relatively low. This hypothesis is supported by the additional evidence that when jointly resolved conflicts did occur in the roles condition, they lasted significantly longer. This may be because children given a role with responsibilities and tool ownership were more attached to their positions, thus it took longer for them to reach a resolution satisfactory to both parties. Whether this extended period of dialogue involved a deeper negotiation around values that benefited their learning about sustainability is an important area for investigation. Follow-up work is currently underway to investigate this through both a qualitative examination of the dialogue episodes and a quantitative assessment of changes in understanding.

Limitations

There were several limitations to this study relating to the relatively small sample size, children with atypically high prior knowledge and experience collaborating, and the high bar of coding criteria for in-depth events. Future work should expand the number and diversity of children studied with an updated coding protocol.

Conclusion

This paper presented an in-vivo experimental study of the effects of assigning children roles with associated tools in a sustainable land-use planning game. Contrary to some previous findings, all pairs in both conditions were found to work together (rather than in parallel / competitively) the entire time. Results showed that pairs given specific roles/tools gave more in-depth explanations to their partners about what they wanted to do in the game than pairs not assigned roles and tools, but did not negotiate with each other in-depth more frequently. This reflects a trend of explanation over negotiation in the sample more broadly. Pairs assigned roles also had fewer but longer instances of jointly resolved conflict. Thus our general finding is a somewhat limited, but consistent, positive effect of the assigned roles/tools manipulation on collaborative processes.

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