Appeared in "Proceedings of ICLS 2000." Ann Arbor, MI, June 2000.

Uneven Achievement in a Constructionist Learning Environment

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Abstract: MOOSE Crossing is a text-based virtual reality environment (or "MUD") designed to be a constructionist learning environment for children ages 8 to 12. We performed a portfolio-style assessment of children's programming accomplishments in this environment. Analysis of the data reveals uneven levels of achievement—some children accomplish a great deal but the majority learn little. We believe this to be a typical problem in self-motivated learning environments. We conclude by describing a new "merit badge" system we are currently implementing to help alleviate unevenness in children's achievement.

Keywords: Constructionism, Self-motivated learning, CSCL, Portfolio assessment.

From Vision to Reality

In *Mindstorms*, Seymour Papert has a vision of a "technological samba school." At samba schools in Brazil, a community of people of all ages gather together to prepare a presentation for Carnival. "Members of the school range in age from children to grandparents and in ability from novice to professional. But they dance together and as they dance everyone is learning and teaching as well as dancing. Even the stars are there to learn their difficult parts" (Papert, 1980). People go to samba schools not just to work on their presentations, but also to socialize and be with one another. Learning is spontaneous, self-motivated, and richly connected to popular culture. Papert imagines a kind of technological samba school where people of all ages gather together to work on creative projects using computers.

This paper examines one obstacle in making this vision a reality: the problem of uneven achievement. MOOSE Crossing is a text-based virtual reality environment (or "MUD") whose design was inspired by the idea of a technological samba school. In this online world, children learn in a constructionist (Papert, 1991) fashion, creating magical places and creatures that have behaviors. In the process, they learn creative writing and object-oriented programming. Past research on MOOSE Crossing has focused on the power of the Internet to create a supportive, community context for constructionist learning (Bruckman, 1997; Bruckman, 1998). However, observations of children using the environment over four years since its founding in October 1995 have revealed a problem: achievement is uneven. While some children excel, others do little. In this paper, we use portfolio scoring (Baron & Wolf, 1996; Chi, 1997) techniques to document that unevenness. We conclude by proposing some new approaches to countering this problem.

Portfolio Scoring

We randomly selected 50 children from the 803 total MOOSE Crossing users (as of November 1999). All chosen kids were under the age of 18 during their time of participation, and all had logged into the system at least once. Of the 50 kids selected, we had 23 girls and 27 boys. Further information about the children and their level of involvement can be found in Table 1. Degree of participation is a key factor to track, and in most research is typically measured by time on task. On MOOSE Crossing, as in many online environments, time on task is not equivalent to total connection time. Many users may be multitasking, or just leave themselves logged in and inactive for long periods of time. Therefore, in order to get a more accurate measure of time on task, we chose to count the number of commands issued by each child.

We performed a portfolio-based assessment of each participant's scripting ability. While children do significant creative writing as well as programming in this environment, the writing data is harder to interpret since children can learn to improve their writing from a variety of sources. For this reason, we are focusing this analysis on their programming ability. Each child's portfolio contains all the scripts the child has written on MOOSE Crossing. Two independent judges reviewed and scored the portfolios. The children were scored on their highest level of achievement using the following scale and criteria:

0: Wrote no scripts
1: Demonstrated understanding of basic input/output
2: Used variables and properties
3: Performed list manipulation and flow control
4: Demonstrated mastery of all aspects of the system

In the cases where the judges did not agree, a third judge determined the child's final score.

	Minimum	**Maximum**	**Median**	**Mean** *(std. dev)*
Age	7	17	12	12 *(2.3)*
Period of Participation	7 minutes	4 years, 1 month	3 months, 25 days	9 months, 12 days *(1 year, 1 month)*
Commands Typed	6	51,850	788	6,638 *(11,958)*
Scripts Written	0	234	2	19.5 *(43.3)*
Portfolio Score	0	4	1	1.36 *(1.47)*

Table 1

Results

The children we examined exhibit uneven levels of both participation and programming achievement in MOOSE Crossing (Table 1). It is clear that while some of the users have attained a high level of programming mastery, a larger subset have not written any MOOSE scripts at all (Figure 1).

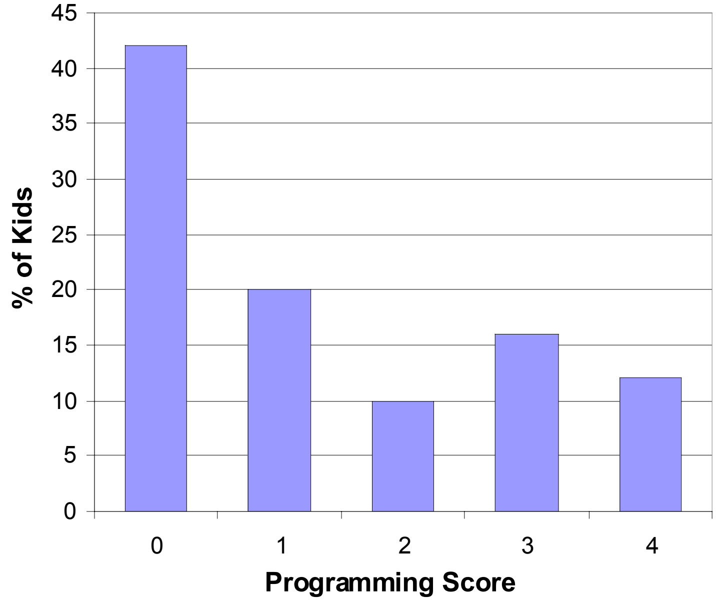

Figure 1

This supports our informal observation that a small subset of MOOSE users are deeply involved and learn significant programming skills, but a large portion of the community learns only the most basic programming concepts. Despite a reasonable sample size (50 of 405, 12% of children participating), the standard deviations on all mean values are high. The difference between the mean and median scores shows that a small group of kids are greatly offsetting the average. The mean time-on-task of 6638 commands typed and the median of 788 shows that a few enthusiastic users are spending enormous amounts of time on MOOSE Crossing, while the majority are much less active. The median number of scripts written is only 2, as opposed to the mean of 19.5. Again, a very active part of the community is skewing the average score, whereas the median presents a more realistic measure of participation.

In order to address this uneven level of achievement, we have considered several influences on children's programming performance in MOOSE Crossing. We recognize that users with previous exposure to some form of programming are likely to do better. In addition, we must consider the obvious relation between the users' time-on-task and their achievement. Finally, we pose some interesting questions about the relevance of gender and home versus school use on the children's participation and programming scores.

Prior programming experience is an influential factor on achievement. For the purposes of this study, we considered use of any programming or markup language (such as HTML) as prior programming experience. Of the 50 kids, 16 had some form of previous programming experience (4 girls and 12 boys). As expected, the kids with previous exposure achieved significantly higher scores than those without ($p<0.05$ (Mann-Whitney Test)). There was no significant difference between the time-on-task between the two groups ($p>0.05$ (Non-Pooled T-Test)). The children with previous experience had a mean score of 2.4 and a median of 3; those without achieved only a mean score of 0.9 and a median of 0 (Figure 2). It is interesting to note that the group with prior experience consisted mostly of boys. Only 17% of the girls had previous experience, compared with 44% of the boys.

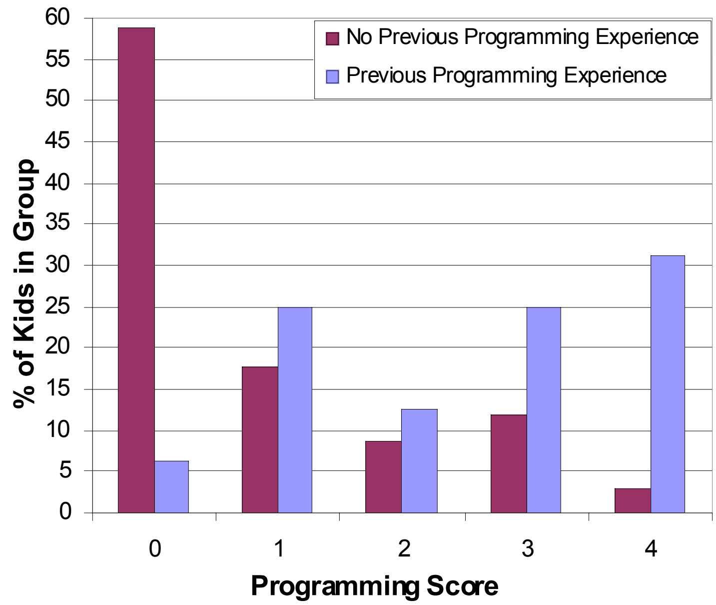

Figure 2

We are not surprised that our data supports the established concept that time-on-task is directly related to achievement. However, we are encouraged by the logarithmic trend in the children's programming scores based on the number of commands typed. The users who made it past the initial threshold usually went on to create more complex projects. This illustrates that the amount of participation required to gain understanding of more complex programming concepts in MOOSE Crossing is low. It does not appear that gender affects this trend, as shown by the nearly identical curves for both boys and girls (Figure 3).

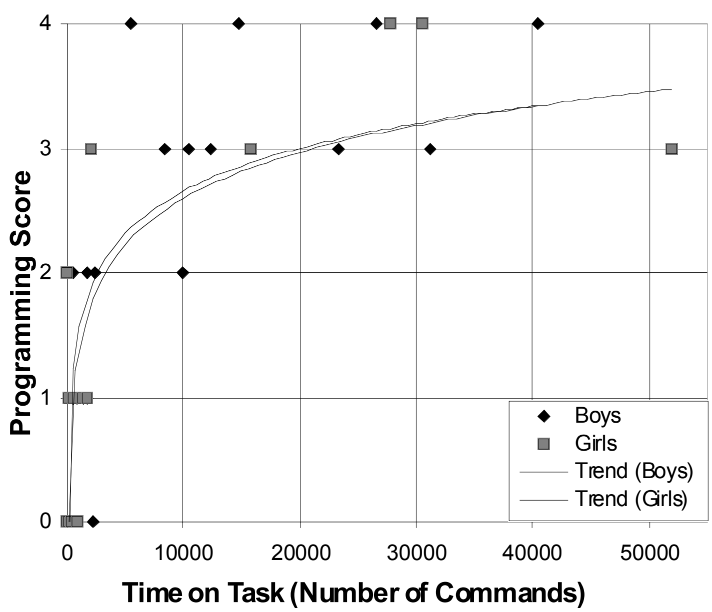

Figure 3

Noting the heavy gender bias with previous programming experience, we examined whether programming achievement on MOOSE Crossing is directly related to gender (Table 2). While the boys had a higher mean programming score (1.63 boys, 1.04 girls) and a higher median score (1 boys, 0 girls), the curves for both boys and girls have the same approximate shape as the composite (Figure 4) The slightly higher performance of the boys may be explained by their prior programming experience and slightly higher time on task, but these differences are not significant. Our data indicates that gender does not affect the kids' level of achievement or involvement (p>0.05 (Mann-Whitney Test for programming scores and non-pooled T-Test for involvement)).

	Minimum		**Maximum**		**Median**		**Mean** *(std. dev.)*	
	Boys	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**
Age	7	7	17	16	12	11	12 *(2.23)*	12 *(2.36)*
Period of participation	7 min	13 min	4 yrs, 1 mo	3 yrs, 5 mo	4 mo, 28 days	3 mo, 1 day	10 mo, 23 days *(1 year, 1 mo)*	7 mo, 24 days *(11 mo, 21 days)*
Commands typed	6	41	40,436	51,850	1,632	241	7,267 *(10, 974)*	5,900 *(13,233)*
Scripts written	0	0	234	124	8	0	26.6 *(52.8)*	11.3 *(27.2)*
Portfolio score	0	0	4	4	1	0	1.63 *(1.50)*	1.04 *(1.40)*

Table 2

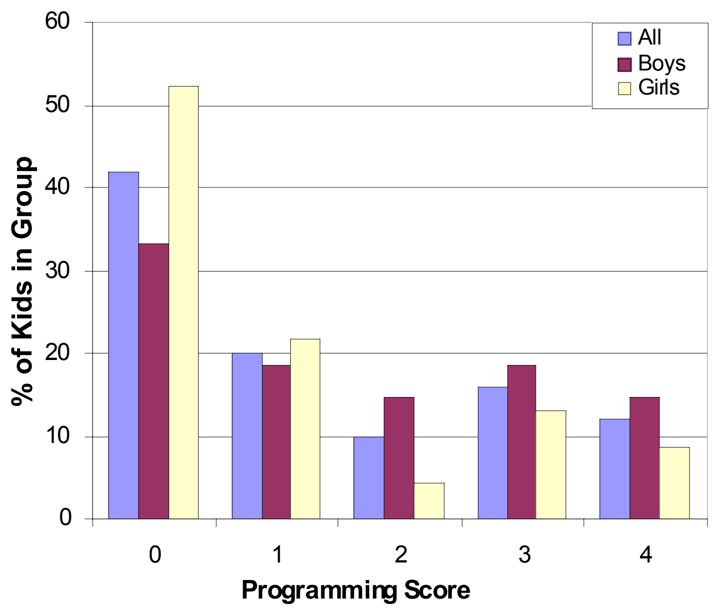

Figure 4

MOOSE Crossing is used in-school (42% of participants), in after-school programs (8%), and as a free-time activity (50%). We found no significant differences in time-on-task or programming achievement (Figure 5) among these groups (p>0.05 (Non-Pooled T-Test for time-on-task and Mann-Whitney Test for achievement).

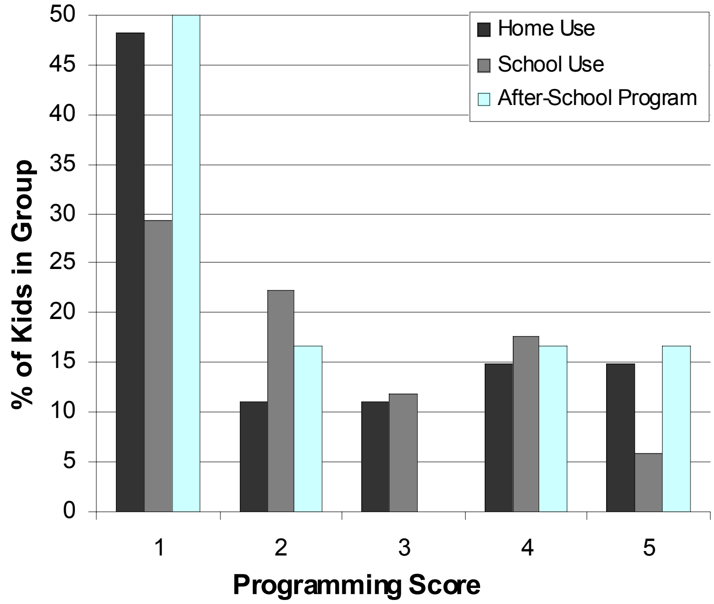

Figure 5

Future Work: Combating Unevenness

We do not believe this unevenness to be a problem unique to MOOSE Crossing, but rather a fundamental issue that arises in the design of many learning environments, especially self-motivated ones. In a self-motivated learning environment, we give students freedom to choose whether to get involved in the hopes that they will embrace the opportunity with genuine enthusiasm. However, inevitably some will decline what is offered.

We take it as a given that unevenness of achievement is undesirable. This is particularly true for an in-school activity. A free-time activity can't be expected to appeal to all children, and unevenness in both interest and achievement is acceptable. However, for an in-school activity, we have a greater expectation that a large percentage of children should benefit at least to some degree, or the activity should be removed from the curriculum.

How can we begin to remedy this problem without spoiling the open-ended, self-motivated nature of the learning environment? Children using MOOSE Crossing in school are generally given a great deal of freedom in how they spend their time online. We do not want to require specific programming tasks be accomplished, but to encourage the students to chose to learn more. Towards this end, we are designing a new system of merit badges. Children will be able to earn badges for a variety of programming, writing, and community service tasks. To earn a badge, a child first finds a sponsor. A sponsor is someone who already has earned that badge (or one of a group of community leaders designated to give badges to the first applicants). With help from the sponsor, the applicant prepares a project portfolio demonstrating understanding of the designated concept (for example using a conditional statement, using a property reference, writing something funny, writing something beautiful, etc.). When the student and sponsor feel the portfolio is ready, it is submitted for anonymous review. If the reviewer approves the application, the student is awarded the badge. The sponsor is also rewarded for this achievement: sponsoring one other person changes your badge in that area to silver, sponsoring five others changes it to gold. When you have a gold badge, you are eligible to be an anonymous reviewer for that badge. When you have earned ten gold badges, you are eligible to lead the monthly community badge presentation ceremony.

Thus, the new merit-badge system combines elements of portfolio assessment and peer tutoring (Johnson & Johnson, 1987). We hope this will raise the level of achievement without spoiling the self-motivated nature of the learning environment. We also hope that this system will help teachers to structure the use of MOOSE Crossing in their classrooms. In informal conversations, teachers using MOOSE Crossing have expressed great enthusiasm for this addition to the learning environment. One teacher commented that she would like to use the badge system as a form of assessment for her students: they will be assigned to earn a certain number of badges during the course of the school year. Unfortunately, using the badge system as an assessment detracts from the self-motivated nature of the learning environment. It is possible that this change will negatively impact the atmosphere of the online community. We are attempting to achieve a delicate balance between a radical constructionist perspective (which eschews assessment and insists that the project should be its own reward) and a more traditional perspective (which sees assessment as an essential component of any learning environment that can meet the demands of functioning in real classrooms). After the introduction of the badge system in early 2000, we plan to perform a detailed study of changes in both students' perceptions of the learning environment and in their level of achievement.

References

Baron, J. B., & Wolf, D. P. (Eds.). (1996). Performance-Based Student Assessment: Challenges and Possibilities. Chicago: University of Chicago Press.

Bruckman, A. (1997). MOOSE Crossing: Construction, Community, and Learning in a Networked Virtual World for Kids. PhD dissertation, MIT.

Bruckman, A. (1998). Community Support for Constructionist Learning. Computer Supported Cooperative Work, 7, 47-86.

Chi, M. T. (1997). Quantifying Qualitative Analyses of Verbal Data: A Practical Guide. Journal of the Learning Sciences, 6(3), 271-315.

Johnson, D. W., & Johnson, R. T. (1987). Learning Together & Alone. Englewood Cliffs, NJ: Prentice-Hall.

Papert, S. (1980). Mindstorms: Children, Computers, and Powerful Ideas. New York: Basic Books.

Papert, S. (1991). Situating Constructionism. In I. Harel & S. Papert (Eds.), Constructionism (pp. 518). Norwood, NJ: Ablex Publishing.

Acknowledgements

The authors would like to thank past contributors to the MOOSE Crossing project, especially Mitchel Resnick, Austina DeBonte, Will Scott, Steve Shapiro, Trevor Stricker, and Steve Tamm. Special thanks to the kids of MOOSE Crossing and their parents. Research in the Electronic Learning Communities group at Georgia Tech is supported by grants from IBM, Intel, Microsoft, Neometron, Ricoh, and The National Science Foundation.