Final Report

An Evaluation of Intel's Design and Discovery Summer Program

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Executive Summary

We evaluated the effectiveness of Intel's *Design and Discovery* curriculum as it was implemented during the summer of 2004 at four separate locations in the greater Phoenix metropolitan area. These four areas included one fifth-grade classroom located in an elementary school (J.B. Sutton) and three Intel Computer Clubhouses (Chandler, Guadalupe, and Sacaton), located in branches of the Boys & Girls Clubs of the East Valley.

According to Intel's Design and Discovery website http://www.intel.com/education/Design, the Curriculum is composed of "hands-on engineering and design activities intended to foster knowledge, skill development, and problem-solving in the areas of science, engineering, and technology." The overarching goal of this project was to evaluate the degree to which the curriculum achieves these broad objectives. Specifically, the design of our evaluation was chosen to address three main components of the Design and Discovery Summer Program (DDSP): (1) the school-age participants (students); (2) the teachers or Clubhouse Coordinators who facilitated implemented the program (facilitators); and (3) the Design and Discovery curriculum. We utilized four data collection instruments during the course of our evaluation, including a timed-interval observation protocol, a cognitively-focused instrument, an affectively-focused instrument, and a program implementation survey. Two evaluators spent over 40 hours observing the implementation of DDSP at the four sites. Listed below are a number of our findings.

Student Component Findings:

- DDSP participants gained a significant amount of curriculum-related knowledge as a result of their participation in the program.
- Participants' reported interest in engineering and their self-efficacy related to engineering skills were significantly higher after participation in DDSP than before entering the program.
- Female DDSP participants reported significantly fewer negative perceptions about engineering after participation in DDSP than before entering the program.
- Program participants spent the majority of their time in the program working at the whole class level.
- The participants spent a third of their time in the program engaged in hands-on activities.
- The most frequent type of interaction was facilitator-driven.

- Participants spent the majority of the time actively involved by either responding to the task/facilitator or co-constructing meaning with him or her.

- For the most part, participants demonstrated moderate to high levels of engagement throughout the entire program.

- The major cognitive activity that we assumed occurred as a result of interacting with the curriculum was knowledge construction

- Facilitators rarely used technology.

- Participants rarely used technology.

- The student guide was not used the majority of the time, particularly in the clubhouses.

Facilitator Component Findings:

- The facilitators perceived that their grasp of the curriculum and how to implement it remained relatively stable before and after the program.

- Formal learning settings (school) utilized the Student Guide more regularly than the informal learning settings (Clubhouses).

- Formal setting participants appeared to more frequently engage in knowledge representation than their peers participating in the informal learning environments.

- Facilitators observed clear signs of interest towards the curriculum on the part of students, not just in the classroom, but outside as well.

- Facilitators perceived that the Design and Discovery curriculum was more appropriate for children in middle school as opposed to the stated target grade level of the curriculum (fifth grade).

- Facilitators often adapted or selectively implemented the activities in the Facilitator Guide to fit them within time constraints or to maintain student interest.

Curriculum Component Findings:

- The participants' strong performance on the cognitive instrument and their responses to the affective instrument, which captured increased interest in engineering and self-efficacy related to engineering skills, indicate that the curriculum's core messages are being communicated to students.

- Site facilitators emphasized either the design concepts or the hands-on activities, but rarely both.

Background

Intel's *Design and Discovery* Summer Program

We evaluated the effectiveness of Intel's *Design and Discovery* curriculum as it was implemented during the summer of 2004 at four separate locations in the greater Phoenix metropolitan area. These four areas included one fifth-grade classroom located in an elementary school (J.B. Sutton) and three Intel Computer Clubhouses (Chandler, Guadalupe, and Sacaton), located in branches of the Boys & Girls Clubs of the East Valley.

The Design and Discovery curriculum in its entirety consists of 18 sequential, 2.5 hour sessions, each consisting of between two and four hands-on activities. The curriculum begins by introducing the participants to a 10-step design process that becomes the basis of all future sessions. One of the hallmarks of the curriculum is that participants are provided opportunities to consider redesigning everyday objects as they begin to conceptualize engineering design. Moreover, hands-on activities engage participants in the design process and lead towards the ultimate goal of producing a prototype design product. The participants learn about each aspect of designing the prototype, including problem identification, selecting materials, mechanics, systems, models, and testing. The final sessions see participants sharing their prototypes with their peers in a showcase event.

The curriculum is supported by comprehensive Facilitator and Student Guides that are available on the curriculum web site. The guides provide detailed instructions on how to organize the sessions, what materials are needed, and how to successfully complete each activity. The guides are available in electronic PDF format on the Design and Discovery website, as well as in printed format to each facilitator.

Areas of Inquiry

According to Intel's Design and Discovery website http://www.intel.com/education/Design, the Curriculum is composed of "hands-on engineering and design activities intended to foster knowledge, skill development, and problem-solving in the areas of science, engineering, and technology." The overarching goal of this project was to evaluate the degree to which the curriculum achieves these broad objectives. Specifically, the design of our evaluation was chosen to address three main components of the Design and Discovery Summer Program (DDSP): (1) the school-age participants (students); (2) the teachers or Clubhouse Coordinators who facilitated implemented the program (facilitators); and (3) the Design and Discovery curriculum. Within each of these components, we addressed specific areas of inquiry. Table 1 below outlines the specific areas of inquiry we attempted to address in our evaluation.

Table 1: *Components and Areas of Inquiry of the Evaluation.*

Component	Area of Inquiry
Students	1. Explore whether the Design and Discovery curriculum fosters knowledge, skill development, and problem-solving in the areas covered by the curriculum. 2. Document the school-age children's motivations to participate in the

	experience, their reactions to the experience and the science and engineering content of the curriculum, and their level of interest in pursuing related topics through future activities. 3. Explore how the school-age participants (a) interact with the Design and Discovery activities, (b) progress through the curriculum in general, and (c) interact with the program facilitators around the curriculum, and (d) interact with their peers around the curriculum.
Facilitators	4. Document the implementation model used by the program facilitators. 5. Document educators' perceptions of young people's responses to the curriculum and of its impact on their interest in science and engineering. 6. Determine whether and how available resources (at the website and in print), training experiences, and/or local contextual factors support or impede program educators' (teachers or clubhouse coordinators) choices about how to implement the curriculum, and their ability to implement it effectively.
Curriculum	7. Determine to what extent core messages and concepts are being communicated to the school-age participants.

Data Collection Instruments

As part of the evaluation design plan, we utilized four data collection instruments. We created three of the four instruments ourselves and adopted another. A description of each instrument is found below. An explanation and interpretation of data collected using each instrument is referenced as well.

Timed-Interval Protocol Observation Form

We developed this instrument following our initial site observations. We originally intended to record in an open-ended written format what we observed at each site supplemented with videos of the DDSP participants as they were involved in activities. We quickly realized, however, that each site was significantly different from the others and that classroom interactions were much more complex than we anticipated. This necessitated an observation instrument that would aid us in capturing these complexities with a standardized format that would aid us in making cross-site comparisons.

Additionally, we had proposed to collect video data of student interactions with other students, the facilitators, and with the curriculum. We had planned to observe and videotape one location every other day. However, obtaining parental consent to videotape students was a significant obstacle to this method of data collection. Therefore, this instrument was also a product of our need to gather non-video data of such interactions. It also allowed us to observe every location every day, with the exception of one day at one site.

The timed-interval observation sheet allows us to record, at 5-minute intervals throughout a session, several related variables. Taken as a whole, it allows us to paint a detailed moment-by-moment picture of what happened during each session and to describe the various interactions between instructors, students, and curriculum. We recorded variables such as classroom organization, student role, student engagement, use of technology, and use of the Design and Discovery Student Guide. A copy of the instrument and explanation of its use is found in the Appendix A of this report.

Affectively-Focused Instrument

We adapted an existing instrument to deploy as affective survey as our study. The original instrument was developed by Linda Hirsch and her colleagues at New Jersey Institute of Technology. It was recently showcased during a paper session at the 2003 Frontiers in Education Conference co-sponsored by American Society for Engineering Education (ASEE) and Education Society of Institute of Electrical and Electronics Engineers (IEEE). Hirsch and her colleagues designed the instrument specifically to explore high school students' attitudes to and knowledge regarding engineers, engineering careers, and the study of engineering in college.

To suit our needs, we modified their original instrument in several ways. First, we modified the language. Since the original was intended for use with high school-age students, we adjusted the language to accommodate the younger DDSP participants. Second, we shortened the instrument to include only those items that would be relevant to the DDSP participants. For instance, several of the items on the original instrument asked individuals completing it to identify whether they had completed high-school level mathematics courses and to indicate their confidence associated with the course content.

Our version consisted of 34 affective, Likert-scale agreement items, four demographic items, and one open-ended item. To measure the extent to which participating in the Design and Discovery curriculum might change students' attitudes and understanding of engineering, we administered the affective survey on the first day of the program at each site, and again on the final day. This pre- / post- design is the best way to measure any changes. The survey items remained constant for each administration.

The items on the affective instrument were grouped into several factors on two scales identified in the original instrument: Attitudes To Engineering and Engineering Skills Self-Efficacy Scales. The Attitudes to Engineering Scale consists of several factors, including positive aspects of engineering (positive), interest in an engineering career (interest), negative opinions about engineering (negative), and job issues related to engineering (job issues). The Engineering Skills Self-Efficacy Scale consists of two factors including enjoyment of engineering-related skills and self-efficacy of engineering-related skills. Two items on the instrument express stereotypes about how engineers spend their time and one item relates to perceived gender equality in engineering. A copy of the instrument and how the individual items load on the factors is found in Appendix B of this report.

Cognitively-Focused Instrument

Using a similar data collection design as with the affective survey, we developed and utilized an instrument to measure changes in students' knowledge, skill development, and problem-solving in the areas covered by the curriculum. At one site we administered the cognitive instrument on the first day of the program to 22 participants. Upon reviewing those results, we quickly realized that administering the instrument prior to implementation of the curriculum was not necessary. Students had little to no knowledge of the concepts. Basically, after applying a correction for guessing formula (a *random-guessing model* since the examinees were encouraged to omit items they did not know), the number of correct responses provided by the participants was approximately zero. Therefore, we subsequently made the assumption that the students had no pre-existing knowledge—thus, there was no need to administer a pre-test version of the cognitively-focuses instrument. Knowledge gains of engineering design principles were therefore measured by administering the cognitive instrument on the final day of the program at each site.

The number and content of the individual items on the cognitive instrument administered on the final day of the program differed between sites. Only those concepts taught at each individual site were included on the instrument. Students were therefore not tested on concepts to which they had no exposure. There were, however, some students who completed the instrument and had not attended each class session.

A copy of this instrument can be found in the Appendix C section of this report. In this case, the appendix contains the instrument used at the Guadalupe Clubhouse.

Program Implementation Survey

We developed a survey/interview instrument with which to collect data from the program facilitators regarding their implementation of the Design and Discovery curriculum. Specifically, the instrument helps to clarify variables such as facilitators' preparation, understanding of the curriculum, access to resources, and experience, among others.

We asked each facilitator to complete the 12-item survey prior to beginning the program, and again at the completion of the program. The evaluators then discussed changes between the two with the facilitators in an interview. In the interview we sought to gain a thorough understanding of the facilitators' perspectives on implementation, including the strengths/weaknesses of the curriculum and the successes and failures of their efforts.

A copy of this instrument can be found in the Appendix D section of this report.

To help associate specific instruments with specific areas of inquiry, Table 2 below identifies which instrument (or instruments) was used for each specific area of inquiry. The table is annotated according to modification made to the original proposal based on the constraints and affordances associated with the four implementation sites.

Table 2: *Instruments by Components and Areas of Inquiry of the Evaluation.*

Component	Area of Inquiry
Students	1. Explore whether the Design and Discovery curriculum fosters knowledge, skill development, and problem-solving in the areas covered by the curriculum **(Cognitively-focused instrument)**[1] 2. Document the school-age children's motivations to participate in the experience, their reactions to the experience and the science and engineering content of the curriculum, and their level of interest in pursuing related topics through future activities **(Affectively-focused instrument)**[2] 3. Explore how the school-age participants (a) interact with the Design and Discovery activities, (b) progress through the curriculum in general, and (c) interact with the program facilitators around the curriculum, and (d) interact with their peers around the curriculum **(Timed-interval protocol observation form)**[3]
Facilitators	4. Document the implementation model used by the program facilitators **(Retrospective-debriefing and timed-interval protocol observation form)** [4] 5. Document educators' perceptions of young people's responses to the curriculum and of its impact on their interest in science and engineering **(Retrospective-debriefing)** 6. Determine whether and how available resources (at the website and in print), training experiences, and/or local contextual factors support or

		impede program educators' (teachers or clubhouse coordinators) choices about how to implement the curriculum, and their ability to implement it effectively **(Program implementation survey)**
Curriculum	7.	Determine to what extent core messages and concepts are being communicated to the school-age participants **(Cognitively- and affectively-focused instruments)** [3]

[1]As previously noted, we originally proposed to distribute the cognitively-focused instrument before and after the program was implemented at each site. However, only a posttest version was used. Moreover, since each site covered varying amounts of the curriculum, several versions of the instrument were created, each tailored to the implementation site. Also, we did not use *portfolio-based analytic techniques* to analyze the participants' *Design Notebooks* since the participants at only one site (J.B. Sutton) were encouraged to use them.

[2]We did not design and distribute a *home-improvement use survey* since only one facilitator (J.B. Sutton) intermittently used the Home Improvement tasks from the curriculum.

[3]Replaced *video-based evidence*.

[4]We supplemented the retrospective debriefings with data from the timed-interval protocol observation form.

Procedure

Two evaluators observed the implementation of DDSP at the four sites. At least one evaluator was present each day the program was held at each site. During the first two days of observations, the evaluators observed sites together and completed the Timed-Interval Observation Protocol form in an effort to maximize the inter-rater reliability of the protocol. Inter-rater reliability was .90.

When observing a session, the evaluator would arrive before the class began to speak briefly with the facilitator about the agenda for that day's session. Once the session ended, the evaluator would again speak with the facilitator to assess how closely the class adhered to the agenda. If there were deviations or adjustments made, we attempted to understand the need for such.

While the class was in session, evaluator observed from an area of the room apart from the facilitator-student interaction so as to not be a distraction. The evaluators found that students were only slightly distracted the first day of our attendance, and rarely took notice of them thereafter. Every five minutes the evaluators completed the timed-interval observation protocol to capture a snapshot of classroom activity and interaction. Thus, if the session lasted one hour, the evaluators would record 12 such snapshots.

To avoid observer bias, the two observer/coders counterbalanced themselves across the sites after the two joint observations. Moreover, they avoided staying at one location more than two consecutive times.

Findings – Site Observations

J.B. Sutton Elementary School

J.B. Sutton was the only school setting where we observed the curriculum being implemented. This fact is responsible for several stark contrasts in how DDSP was implemented here as opposed to the other three sites. The most obvious difference was that the program was held for approximately 4 hours each session. The program lasted two weeks, between June 14th and June 24th, with sessions held daily. By completion of the two weeks, the class had completed each activity in Sessions 1 through 5.

Attendance at the J.B. Sutton site fluctuated between a high of 6 students and a low of 2 students. There were 6 students present on the second day of the program, and only 2 students on the final three days. 4 of the students were male; 2 were female. All were entering the 6th grade.

J.B. Sutton Elementary School is part of the Isaac Elementary School District, and is located west of downtown Phoenix. The 2002-2003 Arizona School Report Card (accessed 7/28 at http://ade.state.az.us/srcs/ReportCards/52352003.pdf) labels the school as "Underperforming." For informational purposes only, the same document indicates that, on the 2001-2002 AIMS test for Mathematics, 25% of 3rd graders and 22% of 5th graders at J.B. Sutton met or exceeded the standard. The neighborhoods and community which it serves are largely Hispanic. Each of the 6 students who participated in Design and Discovery at J.B. Sutton were of Hispanic background, and for each, English was a second language.

The teacher was familiar with each of the students, and had some of them in her 5th grade class the prior school year. There was a noticeably formal teacher-student relationship in the classroom. That is, the teacher thoroughly explained difficult concepts; the class frequently read and discussed materials together; desks were arranged such that students faced each other and the teacher; students addressed the teacher by name; students generally raised their hand before speaking; and there was very little off-task behavior, with the teacher keeping strict control. Behaviors indicative of such a formal student-teacher relationship were not generally observed at the non-school sites.

There were other features we observed at the J.B. Sutton site that differed from the others. The teacher followed the curriculum fairly strictly as it is set out in the Facilitator Guide. She kept a binder with the Facilitator Guide at her desk and used it for each session and activity. She also provided photocopies of the day's activities and readings from the Student Guide to each student each day. The class frequently read sections of the Student Guide together, and discussed the concepts and stories they read. Additionally, students were given notebooks on the first day of the program that they used as design notebooks. They drew concept designs, such as their redesigned backpack (Session 2, Activity B), and wrote ideas in their notebooks frequently. Each day of the program, the teacher would cover two to three activities, blending lectures and explanations with hands-on activities and student presentations. At the end of each day, students were given some homework from the Student Guide to complete and bring to class the following day.

Factors Influencing Implementation at J.B. Sutton

We highlight below four factors that had an influence on how DDSP was implemented at the J.B. Sutton site. Each factor is identified, along with an explanation of how it influenced implementation. The factors are not listed in order of importance or severity of impact.

Table 3: *Factors Influencing Implementation at J.B. Sutton*

1.	As we mentioned previously, there were never more than 6 students in attendance for Design and Discovery at the J.B. Sutton site. Despite low attendance, the facilitator adhered to the Facilitator Guide, implemented each activity, and divided the students into pairs and groups to

	work together. Facilitators at other sites where many more students attended utilized the same strategies (with the exception of using the Facilitator Guide). However, the attendance at J.B. Sutton was much lower than the facilitator hoped and expected. When she acknowledged that not only were no more students coming, but also realized that 4 of the 6 stopped, her motivation and excitement for the program suffered noticeably. She felt unsupported, and that the program had not been supported by administration and parents.
2.	The second factor affecting implementation at J.B. Sutton is one that is a result of it being a school setting. The students perceived the facilitator at this site differently than students at non-school sites perceived their facilitators. Having a teacher facilitate the program at J.B. Sutton, we believe, led directly to higher student engagement. The position of a teacher demands a level of comportment and respect to which students at other sites did not feel bound. In saying this, we are not judging one context better or worse than another. Rather, our interpretation of observation data concludes that when the facilitator is perceived by students as an authority figure, rather than a peer or buddy, students are more engaged in learning.
3.	The third factor that distinguished implementation at J.B. Sutton is the facilitator's strict adherence to the written curriculum. As described previously, she followed the outlined curriculum as found in the Facilitator and Student Guides each day. Her use of the Guides included the readings, activities, reference web sites, and video demonstrations on the Design and Discovery web site. Obviously, this model of implementation exposed students to more of the design principles and concepts than were those students whose facilitator did not utilize the Guides as frequently.
4.	However, the facilitator at J.B. Sutton noted several difficulties with the Guides and the curriculum as written. Because her students were English language learners, often the vocabulary used in the Student Guide was beyond their understanding. To compensate, she spent significant time explaining and discussing words and concepts that was intended to be spent involved in activities. Similarly, students required much more time to complete activities than is prescribed in the curriculum. She also found some directions, web sites, and references confusing or of little help.

Sacaton Computer Clubhouse

The DDSP began at the Sacaton Computer Clubhouse on June 15th and was to be held on Tuesdays and Wednesdays each week for approximately one hour in the afternoon. The program was actually held only three times during the seven weeks we were conducting site observations. Every session of program at Sacaton was cancelled after June 29th. Occasionally when a cancellation occurred, the facilitator would reschedule but the rescheduled session would also be cancelled. As can be expected, we were able to collect very little data regarding implementation at this site. In the three sessions held at Sacaton, the class had been introduced to the design process, completing the three activities in Session 1.

On the initial day of the program at Sacaton, 7 students were present. The number of students decreased each day, however. When the program was announced earlier in the summer there was a tremendous amount of interest from the community. About two-thirds of the students at this site were male, one-third female. Each as a 6th or 7th grader between the ages of 10 and 14. The ethnic background of most of the students was Native American.

Each day the program met, the class typically worked on one activity. To complete a session as outlined in the curriculum would take more than one day. While the program was planned to last a full hour, instruction usually lasted 20-30 minutes.

The Sacaton program employed two facilitators. At the beginning of each class, they would gather the students around the table in the center of the room. Interaction was predominantly in the form of hands-on activities, although the facilitator did discuss concepts and work with the students on the activities, providing suggestions, hints, and feedback.

Since so little observation data exists, the instructional methods described here apply only to the first session of the curriculum. It is also difficult to accurately describe the implementation of the program through the lens of our observation variables since the program was held so infrequently. To say that the students were not provided copies of the Student Guide is true, but only for those first few activities. Likewise, to say that homework was not given nor were design notebooks used provides only half the picture of implementation.

Factors Influencing Implementation at Sacaton

We highlight below four factors that had an influence on how DDSP was implemented at the Sacaton Clubhouse. Each factor is identified, along with an explanation of how it influenced implementation. The factors are not listed in order of importance or severity of impact.

Table 4: *Factors Influencing Implementation at Sacaton*

1.	The obvious factor that influenced implementation of Design and Discovery at the Sacaton site was the large number of cancellations of class sessions. This was a source of frustration for the evaluators, although we were informed of the cancellation before traveling to the site. It would be understandable to assume that students and facilitators alike also felt some frustration at not being able to participate in the program regularly. Many of the cancellations were a result of the primary facilitator's need to attend to pressing family matters.
2.	The Sacaton program also employed two facilitators. However, only one of them felt comfortable enough to lead the program. Therefore, in his absence, the program had to be cancelled. Had the second facilitator been more familiar with the curriculum, this would have contributed greatly to the continuity of the program at this site. This fact will be noted again below in discussing the Chandler Clubhouse site.

Chandler Computer Clubhouse

At the Chandler Computer Clubhouse, the Design and Discovery program was held daily over a two-week period. Each class period was scheduled to last one hour in the afternoon, between July 6th and July 16th. In reality, class periods usually lasted between 30 and 45 minutes. Each scheduled period was held; no cancellations occurred. The facilitator at this site had the help of two other staff members, and when she had to be out of town for several of the class periods, the staff members were capable of facilitating the program in her absence.

Student attendance at the Chandler site varied between 10 and 23 students. The first day of the program saw the lowest attendance, and the final day saw the highest. Many of the regularly attending students from the previous week were absent during the second week, while new students began to attend. Approximately two-thirds of the students who attended were male, one-third female. Each was between 12 and 14 years old (7th – 9th grades). There were several ethnic backgrounds represented.

In a typical class period, the class would work on a single hands-on activity from the curriculum. Not each activity from each session was covered. The facilitators seemed to select which activities they wanted to do. We observed the class working on the three activities in Session 1, activities A and B in Session 2, activities A and C in Session 5, and activity B in Session 9. For certain activities, students were provided with photocopies of the Student or Facilitator Guide that provided step-by-step instructions for the activity. The students kept design notebooks.

The instruction and activities always took place around the center table. Although the facilitators would introduce basic design concepts through a brief lecture, the bulk of each class period was spent working on the hands-on activities. The students generally worked in small groups, and facilitators would move from group to group, offering suggestions and feedback. We noted that the students at this site were generally more engaged than at the other Computer Clubhouse sites. Off-task behavior was less frequent.

Factors Influencing Implementation at Chandler

We identified four primary factors that influenced implementation at the Chandler Computer Clubhouse. These are described below together with an explanation of how each influenced implementation.

Table 5: *Factors Influencing Implementation at Chandler*

1.	The primary facilitator at the Chandler Clubhouse has a strong background in formal educational settings, in addition to youth development. Of her 10 years experience, 4 years were spent teaching in Montessori environments. We believe that this formal teaching experience, together with a master's degree, influenced the amount of control she exhibited over the students' behavior. The high level of engagement we observed may in part be attributable to the experience of the facilitator in formal educational settings. Still, she made it clear in our interview that she purposefully tried to implement the program in such a way that it would not "feel like school." For example, there was a greater emphasis on activities than on conceptual lectures, no homework was assigned, and certain sessions were intentionally left out if she felt the students would not enjoy them as much as others.
2.	As with the other Computer Clubhouse sites, because the student population is more transient than in a school setting, it is more difficult to ensure that every student is learning what they would otherwise. While interviewing the facilitator upon completion of the program, she noted that part of the reason behind attendance transience at Chandler was that the program was running during the final two weeks of the students' summer vacation. Thus, many were on vacation with family during part of the program.
3.	The Chandler site used multiple facilitators. Although only one facilitator had been trained in the curriculum, a second was familiar enough with it to lead the class periods in her absence. The facilitators spent time discussing and planning each class, and preparing each activity. We felt that the multiple-facilitator arrangement at Chandler helped to accomplish two things. First, it helped maintain engagement despite a fairly large attendance each day, and second it created continuity. A second facilitator does not necessarily ensure continuity if the second facilitator is not confident to lead the classes. Chandler did not have to cancel the program when the primary facilitator was not present. Students can only benefit when classes are held regularly and led by facilitators familiar with the curriculum.
4.	Sessions at the Chandler site focused on the curriculum's hands-on activities, at the expense of more thorough explanation of design concepts. As mentioned above, at times the facilitators

planned to leave out certain concepts and activities if they felt the students would not enjoy them as much as others. This kind of flexibility, according to the facilitator, helped implementation a great deal by relieving the pressure of trying to engage kids in uninteresting activities. It also helped her to save a lot of time.

Guadalupe Computer Clubhouse

The Guadalupe Computer Clubhouse offered the Design and Discovery program over the course of approximately 7 weeks, from June 15th to July 27th. The program was held twice each week, on Tuesday's and Thursdays, for approximately one hour. During this span of time there were five instances (nearly 40%) when the program was cancelled by the primary facilitator due to off-site obligations or personal reasons. A second facilitator was present at each session, but he was not familiar enough with the curriculum to lead sessions in the primary facilitator's absence. By the completion of our data collection, the class had completed select activity A in Session 1; activities A, B, and C in Session 2; and activity C in Session 5. The facilitator also presented a few design lessons of his own design. For example, he had the students work in small teams to build a bridge out of Legos following specifications he gave them. He implemented this activity to strengthen their teamwork skills as well as their design capabilities.

Attendance at the Guadalupe site fluctuated, but averaged about 25 students each session. Students ranged in age between 7 and 12 years (between grades 2 and 7). At the Guadalupe site were the youngest students of any of the four sites we observed, as well as the broadest range of ages. About 60% of the students were female and 40% were male. Student ethnic backgrounds varied widely.

A typical Design and Discovery session at the Guadalupe Computer Clubhouse would last about 1 hour. In the center of the room is a large table around which the students would gather to begin. The facilitator would start the session by reviewing and presenting design concepts and introducing the activity the students would do that day. The students most often were divided into groups to complete the activity and these groups scattered throughout the room to work. While the groups worked, the facilitators would move between the groups offering help and feedback.

The sessions at this site emphasized hands-on activities more than design concepts, much like at the Chandler site. Students were not given copies of the Student Guide and the facilitator spent little time lecturing or discussing key concepts. Occasionally students would present their work following completion of an activity. Students did not use design notebooks, and were not given homework.

Generally, engagement was categorized as medium (greater than 20%, lower than 80%), although we observed full engagement at times. This means that, generally, more than 20% but fewer than 80% of the students were engaged in the assigned task. We observed frequent off-task behavior on the part of the students, and occasionally we categorized engagement as low (under 20%). There seemed to be many distractions in the room; the students were easily distracted; and it was seemingly chaotic at moments. The facilitator seemed to struggle to capture and maintain the attention of all the students.

Factors Influencing Implementation at Guadalupe

In our observations, we noted four factors influencing implementation at the Guadalupe Clubhouse site. These are identified below together with an explanation of how each factor influenced implementation. Factors are not ordered in terms of importance or severity.

Table 6: *Factors Influencing Implementation at Guadalupe*

1.	Daily attendance at this site was larger than at any other site. There were days when attendance approached 30 students. With only two facilitators, such a large group of students was often not easy to control. Students were often left to themselves, and were quickly distracted from the task at hand. In discussing our observations after only two or three site visits, the evaluators described the class as chaotic at times. The facilitator noted greater engagement and interest during select activities than during others. For example, students seemed to take to the lesson on electricity and the mechanical engineering activity in which they built a crankshaft. That said, in interviewing the facilitator following completion of our observations, he expressed his pleasure in the interest shown by the students. He told of how, on several occasions, students would approach him an hour or more after the session ended and want to return and make changes to what they had done during that day's activity. This, to him, showed that they were engaged enough to continue thinking about the concepts and activities long after the lesson had finished.
2.	The students participating in the program at this site were younger than those at any other site. Many were 7 or 8 years old, in 3rd or 4th grade. We felt that the concepts contained in the curriculum are more complex than a typical student of this age is capable of grasping. In fact, the Design and Discovery web site describe the curriculum as being designed for 11-14 year old students. Younger students will find it more difficult to learn the basic design concepts of Design & Discovery. The age of the students likely contributed to engagement levels.
3.	Student attendance was highly transient. Many students attended the program only once or twice, and very few attended all the classes. This makes it obviously difficult for the student to learn, as each session builds on previous sessions. The facilitator noted that he held some "crash-course makeup sessions" to help students learn what they missed. However, students were not required to attend. This is true of each of the Computer Clubhouse sites held at Boys & Girls Clubs. As it was explained to the evaluators, "[Boys & Girls] Club programs are generally design to operate on a drop-in basis. The Club population is reasonably transient, so programs are implemented with an eye toward non-linear stand-alone sessions" (personal communication with Angie Finnell, Boys & Girls Clubs Clubhouse Manager, 7/21/04). Design and Discovery has not been designed to be implemented in this way.
4.	We feel that the background of a program facilitator can contribute greatly to the implementation of Design & Discovery. When a facilitator has work experience in formal educational settings, he or she will implement the program based on that experience. A facilitator without experience in formal education settings will implement in other ways. We noted this factor at each of the Clubhouse sites, in contrast to what we noted above at J.B. Sutton. Implementation at the Clubhouses focused primarily on engaging students in hands-on activities, and less on teaching design concepts. Very little time was spent either lecturing on key concepts from the curriculum or discussing them as a class. Students learned to do each activity, but not the engineering concepts that formed the basis of those activities.

Findings – Descriptive and Quantitative Data

Due to extremely high attrition rates across the sites, we concluded our evaluation with only twelve participants with complete data. Of the twelve students, two students were from J. B. Sutton, three from Guadalupe, and seven from Chandler. Table 3 below reports the demographic characteristics (age, ethnicity, gender, and grade) of the participants by location.

Table 7: *Demographic Characteristics of Participants by Location.*

Location	Participant Demographics
J.B. Sutton	• An 11-year-old Hispanic female enrolled in sixth grade Fall 2004 • An 11-year-old Hispanic male enrolled in sixth grade Fall 2004
Guadalupe	• A 9-year-old, White female enrolled in fourth grade Fall 2004 • A 10-year-old, Hispanic female enrolled in fifth grade Fall 2004 • An 11-year-old, Native American male enrolled in sixth grade Fall 2004
Chandler	• Three 12-year-old Hispanic males enrolled in seventh grade Fall 2004 • A 12-year-old African American female enrolled in eight grade Fall 2004 • Two 13-year-old White males enrolled in eighth grade Fall 2004 • A 13-year-old Female enrolled in eighth grade Fall 2004

In light of the overall small sample size, we elected to forego the use of inferential statistics, which are not robust to violations of their assumptions (e.g., normality), to conduct our analyses in favor of non-parametric statistics, which are better suited for situations with unequal sample sizes and non-normality due to small sample sizes, both of which can seriously bias parametric tests. Typically, non-parametric tests are used as substitutes for parametric techniques in situation when the data: (a) do no meet the assumptions needed for a standard parametric test, and/or (b) consist of nominal or ordinal measurements, so that it is impossible to compute standard descriptive statistics (e.g., mean, standard deviation). Since our evaluation met the criteria for their use, non-parametric statistics were used. Unless otherwise noted, each of the statistical tests reported in this section was conducted at the conventional alpha level of .05.

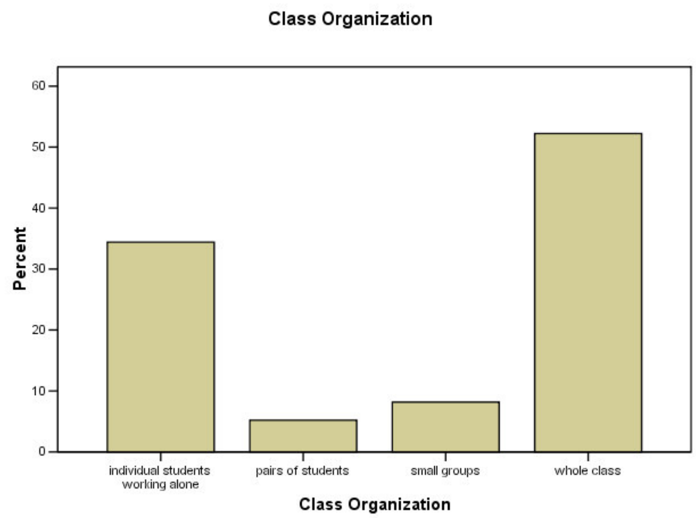
Timed-interval Protocol Observation Form

We coded a total of 503 timed-intervals (five minute intervals) across all four locations; in other words, we observed a total of approximately 42 hours worth of the DDSP. At each interval, we coded for nine categories (see Appendix A) including class organization, type of instruction, classroom interaction, student role, student engagement, cognitive activities, technology integration by teacher, students' technology use, and students' study guide use. We compiled these observations into a data set, which permitted us paint a picture of the DDSP implementation model collapsed across settings as well as the contrasting the implementation models adopted by the formal (J.B. Sutton) and informal learning environments (the Intel Computer Clubhouses).

Characterization of Implementation Model Collapsed across Settings

For each of the nine categories, we created graphs that depict what percentage out of the total intervals that we observed a particular phenomenon occurred, without making any distinction between the individual settings. For instance, Figure 1 below captures the type of class organization that we observed throughout the program. As you can see from the graph, *program participants spent the majority of their time in the program (52.2%) working at the whole class level*. If they were not working in groups, they were likely working individually on projects (34.4%). While participants rarely worked in dyads (5.2%) or small groups (8.2%).

Figure 1: *Observed Class Organizations.*



The following graph (Figure 2) depicts the types of instruction utilized by facilitators we observed throughout the program implementation period. Approximately *one-third (33.6%) of the time in the program was spent engaged in hands-on activities*, followed closely by teacher-led lectures with discussions (19.2%) albeit interruptions or breaks occurred about the same amount of time (19.7%). Often times, we observed two or more types of instruction occurring simultaneously (12.1%). For instance, administrative break occurred while participants were engaged on hands-on activities. One category, teacher interacting with students, is potentially a bit misleading. This refers to events that occur outside of hands-on activities or demonstrations. For instance, the teacher talking with a student about something unrelated to the program.

Figure 2: *Observed Types of Instruction.*

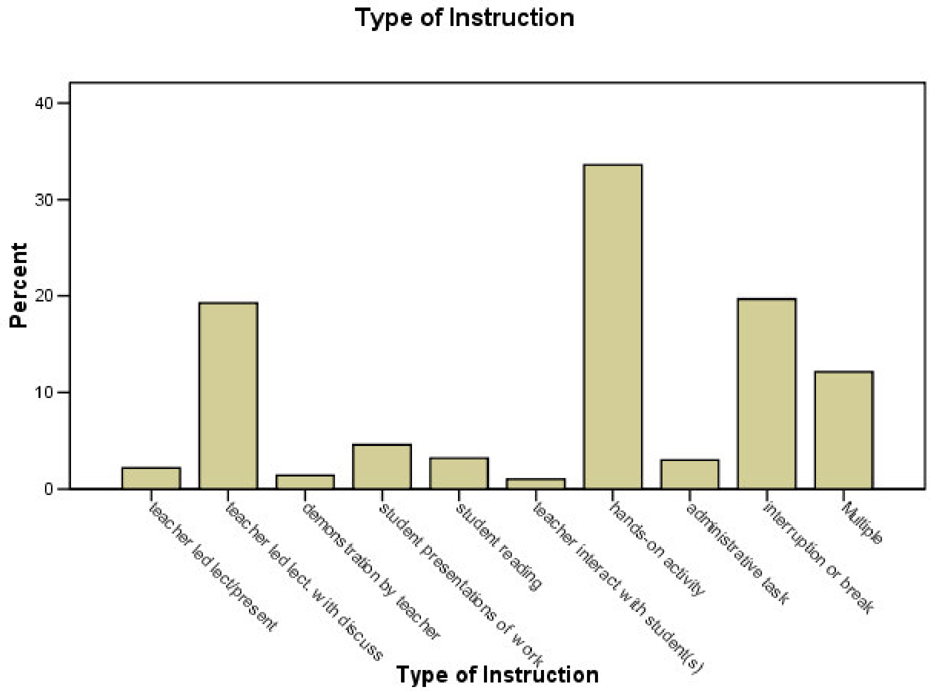


Figure 3 captures the type of interaction that occurred more frequently during our observations. Clearly, *the most frequent type of class interaction we observed was teacher-driven (97.3%).* In other words, the facilitator was responsible for leading instruction, proving little opportunity for participants to take ownership of their learning. On a few rare occasions, the class interaction was student-driven (2.7%), where the students pursued on-topic, appropriate activities that were beyond the scripted curriculum.

Figure 3: *Observed Types of Interaction.*

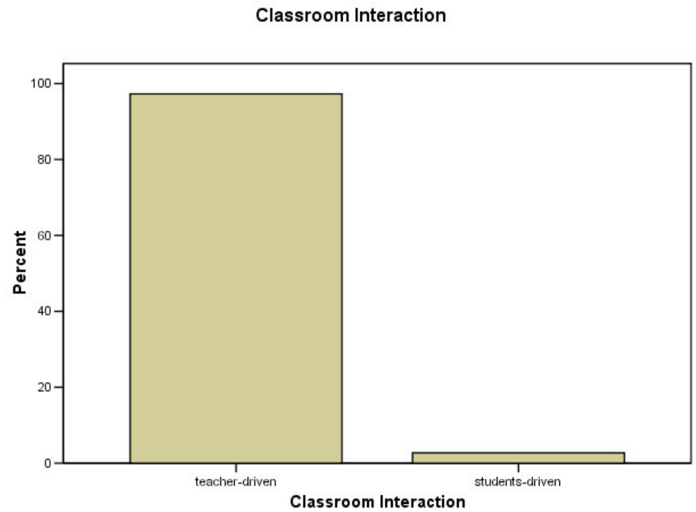


Figure 4 captures the typical student role we observed occurring most frequently during the program. Although a large percentage of the program time involved passive or little response on the part of the participants (41.5%), *the majority of the time they were actively involved by either actively responding (51.2%) to the task/facilitator or co-constructing meaning (7.2%).*

Figure 4: *Observed Student Roles.*

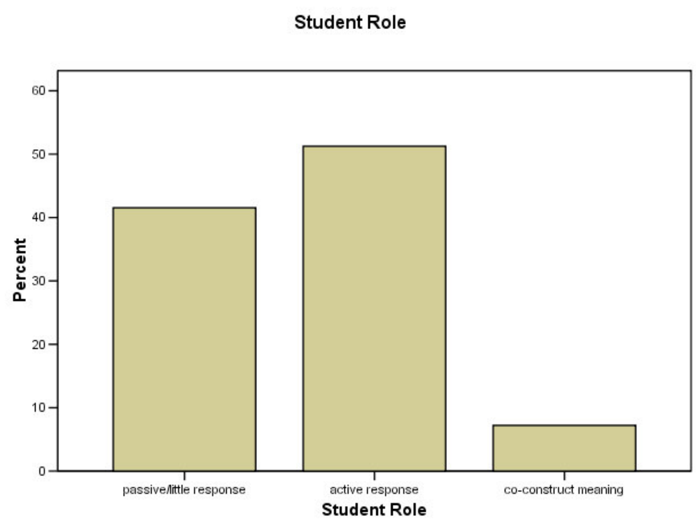


Figure 5 captures the type of student engagement that occurred most frequently during our observations. Fortunately, we saw little evidence of low engagement, only 5.5% of the time. Instead, the *DDSP participants we observed demonstrated either high levels of engagement (71.6%) or moderate (22.9%).*

Figure 5: *Observed Student Engagement.*

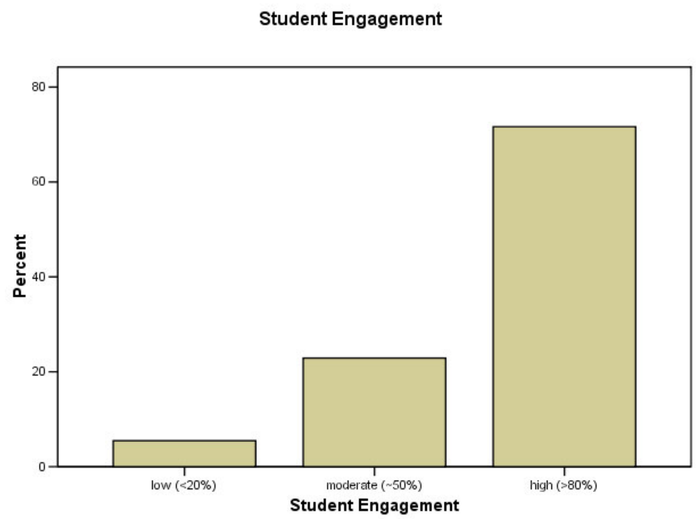


Figure 6 captures the type of cognitive activities that we inferred from observable behavior that occurred more frequently during our observations. We estimated that *the major cognitive activity that occurred during the curriculum was knowledge construction (50.2%).* Of some concern, is the modest rate associated with the cognitive activity that we referred to as receipt of knowledge (35.8%). Occasionally we observed evidence of applied procedural knowledge (5.5%) or knowledge representation (5.2%).

Figure 6: *Observed Types of Cognitive Activities.*

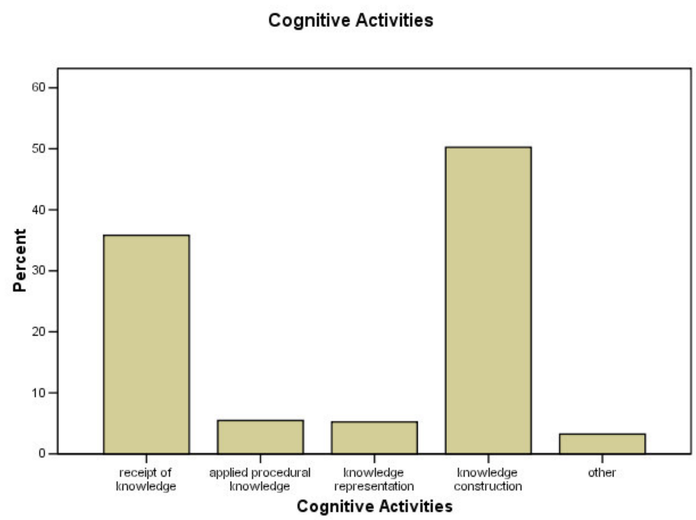


Figure 7 captures the frequency with which we observed technology was integrated into the sessions by the facilitator. *Technology was almost ever used by the facilitator to support the curriculum and associated instructional activities (95.8%).*

Figure 7: *Observed Technology Integration by Teacher.*

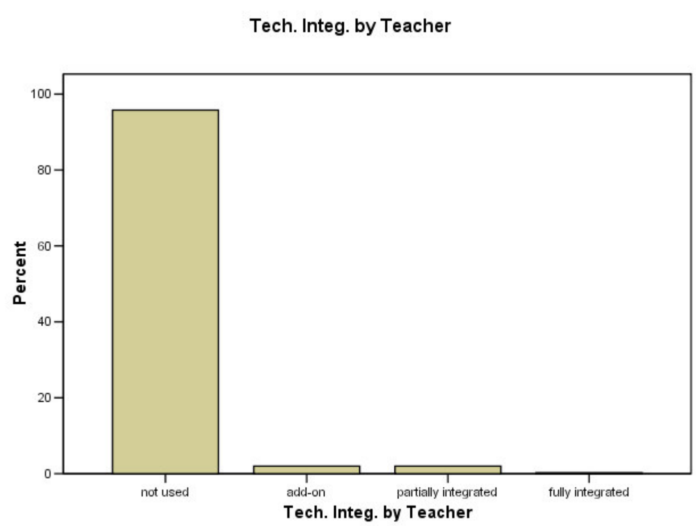


Figure 8 captures the frequency with which we observed technology used by the students during the program. *Students did not use technology the majority of the time (96.8%).* On a few rare occasions (3.2%), participants used the computer to conduct internet searches related to an on-going activity with Microsoft Internet Explorer. These events occurred primarily in the clubhouses.

Figure 8: *Observed Student Technology Use.*

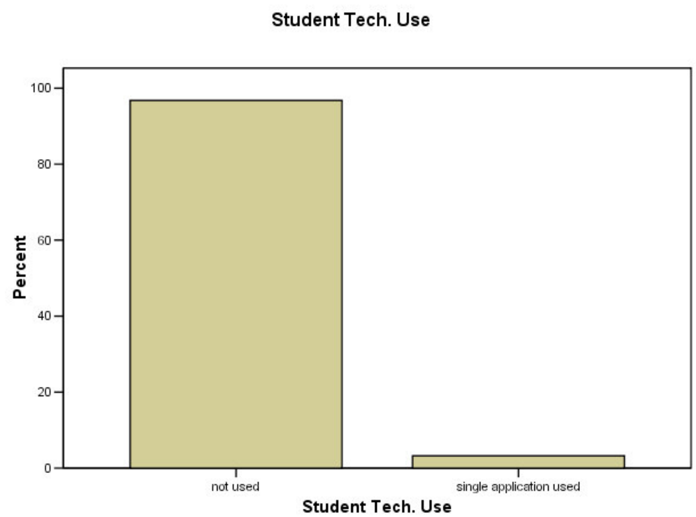
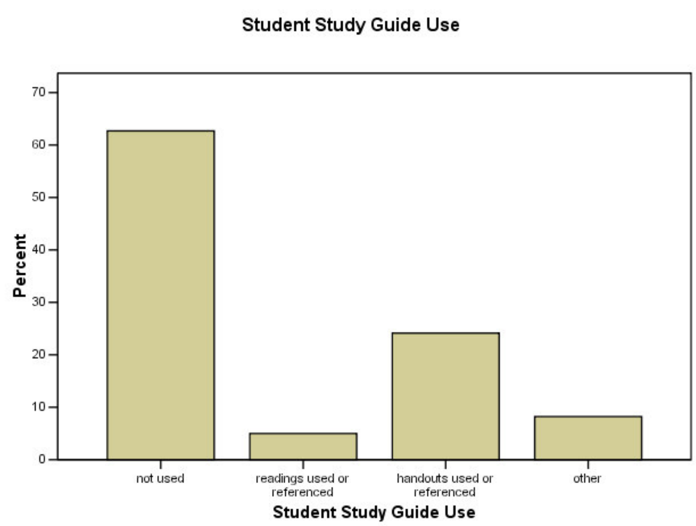


Figure 9 captures the frequency with which we observed the study guide being used or referenced by the students during the program. *The student guide was not used the majority of the time (62.7%).* When it was used, the handouts were the focus (24.1%) although the readings were occasionally used (5%).

Figure 9: *Observed Student Guide Use.*



Comparison of Implementation between Formal versus Informal Settings

We coded for 375 timed-intervals (every five minutes) at J.B. Sutton compared to 128 timed-intervals across all of the clubhouses (every five minutes). Thus, *we observed the DDSP participants at J.B. Sutton spending over 30 hours interacting with the curriculum compared to approximately 11 hours of implementation across all three clubhouses* (5.75 hours at Guadalupe, 1.25 hours at Sacaton, and 3.75 hours at Chandler).

We explored differences between formal (J.B. Sutton) and informal learning environments (the Intel Computer Clubhouses). Of the nine coding categories on the timed-interval protocol observation form, five were coded as ordinal data (class organization, student role, student engagement, technology integration by teacher, and students' technology use) and the remaining four were coded as nominal data (type of instruction, classroom interaction, cognitive activities, students' study guide use). Thus, Mann-Whitney tests were used to examine the ordinal data and chi-square tests for independence were used to explore the nominal data.

Our Mann-Whitney test of the form's ordinal data (class organization, student role, student engagement, technology integration by teacher, and students' technology use) revealed no significant differences in terms of class organization, student role, technology integration by teacher, and students' technology use. However, there was a significant difference observed in terms of engagement. This reflects that fact that the *students at J.B. Sutton (the formal learning environment) spent the majority of the time entirely focused on the learning tasks and most—if not all—of the activities in the classroom were relevant to these tasks. On the other hand, we noted high rates of low-to-moderate engagement in the informal learning environments—the Intel clubhouses combined, characterized by off-task behavior.*

Our chi-square analysis of the form's nominal data (type of instruction, classroom interaction, cognitive activities, students' study guide use) revealed significant differences (1) classroom interaction, (2) cognitive activities, and (3) students' study guide use. First, with regard to classroom interaction, *all of the activities we observed in the clubhouses were facilitator directed.* That is, the facilitators were responsible for structuring and managing all of the learning tasks. *In contrast, at J.B. Sutton we observed at least an hour of student-directed learning or about 4% of the total instructional time.* During this time, the facilitator stepped aside and allowed the participants to complete autonomy over the learning environment. This occurred towards the latter part of the program and in many ways was a watershed event. In fact, we observed that the students were so engaged in directing their own learning that they completely lost sense of time, overlooking a break opportunity in order to keep working.

Second, we noticed differences in cognitive activities between formal and informal learning environments. The *formal setting participants appeared to more frequently engage in knowledge representation than their peers participating in the informal learning environments*. Specifically, we observed the J.B. Sutton participants representing or explaining their original work to their peers as well as elucidating their understanding of curriculum-based concepts in a way that fostered the understanding of their counterparts.

Third, we noticed differences in students' study guide use between the formal and informal learning environments. Whereas the *student guide was used or referenced extensively—about 45% of the time—at J.B. Sutton, it was rarely used or referenced (less than 4% of the time) at the clubhouses*. Of the 45%, we observed the J.B. Sutton facilitator using the study guide readings about a one-third of the time and the study guide handouts about two-thirds of the time. No other significant differences were observed.

Affectively-Focused Instrument

As previously mentioned, the affectively-focuses instrument was administered to the participants before and after the DDSP. Essentially, we used a one-group pretest-posttest design. Since this was one of the more informative instruments we relied on, three sets of analyses were conducted on the affective questionnaire data.

First, an overall analysis was conducted using the data collected from all twelve students. This analysis was intended to examine whether the DDSP positively impacted the participants' attitudes to and knowledge about engineering. Second, we explored the differences across gender by conducting pairwise analyses of the differences in the participants' responses before and after participation in the DDS by gender. Third, we explored the differences across the three sites by conducting pairwise analyses of the differences in the participants' responses before and after participation in the DDSP.

The set of analyses involved rank-ordering the scores for the twelve participants according to the magnitude of the change in their responses to the items associated with the eight factors before and after participation in the DDSP and a Wilcoxon signed-ranks test was used to evaluate the data. We used this test since it permits one to evaluate the data from a repeated-measures experiment, where each individual in the sample is measured twice: once before the treatment and once after the treatment.

The results of this analysis showed a significant increase in responses on two of the affective instrument's subscales. Specifically, the results showed a significant increase in reported interest in engineering ($z = -1.96$, $p < .05$), a subscale of the Attitudes to Engineering Scale. Also, the results showed a significant increase in self-efficacy ($z = -2.43$, $p < .05$), a subscale of the Engineering Skills Self-Efficacy Scale. We cautiously assert that the *participants' interest in engineering and their self-efficacy related to engineering skills appear to have increased as a result of their participation in the DDSP*. No other differences were found.

The second analyses required us to calculate difference scores between the participants' responses before and after participation in the DDSP. These differences were then used as the basis for the pairwise comparisons between males and females. We used a Mann-Whitney test since it is designed to evaluate the differences between two samples.

There was only one significant difference across the various subscales when comparing the responses between males and females. In terms of reported negative opinions towards engineering, a subscale of the Attitudes to Engineering Scale, *in contrast to males that reported no change in negative opinions towards engineering as a result of the DDSP, females reported significant shift on the eight items that emphasize perceived negative aspects associated with engineering* (e.g., "The reward of becoming an engineer are not worth the effort", "From what I know engineering is boring"). The female participants were much more likely to disagree with the statements after participating in DDSP than their male peers ($z = -2.03$).

Similar to the previous analysis, the third analysis required us to calculate difference scores between the participants' responses before and after participation in the DDSP. These differences were then used as the basis for the three pairwise comparisons (e.g., J.B. Sutton versus Chandler, Chandler versus Guadalupe, J.B. Sutton versus Guadeloupe) between the settings for the DDSP. Again, we used a Mann-Whitney test since it is designed to evaluate the differences between two independent samples.

There were no significant differences between any of the affective instrument's subscales between J.B. Sutton and Guadalupe. There were, however, significant differences between J.B. Sutton and Chandler. First, the results showed that the *Chandler participants reported a significantly greater increase in reported interest in engineering than their counterparts at J.B. Sutton* ($z = -2.07$, $p < .05$). However, the *J.B. Sutton participants reported significantly greater positive change in their responses to the survey's gender equity item* ($z = -1.98$, $p < .05$). Specifically, the J.B. Sutton participants demonstrated a more significant shift—from disagreement to agreement—in their response to the statement "[a] women can succeed in engineering such as easily as a man of similar ability" than their peers at Guadalupe. No other differences were found between J.B. Sutton and Chandler.

There were also a significant difference between Chandler and Guadalupe. Specifically, the results showed that the *Guadalupe participants reported a significantly greater increase in reported self-efficacy than their counterparts at Chandler* ($z = -2.08$, $p < .05$). No other differences were found between Chandler and Guadalupe.

Cognitively-Focused Instrument

As previously mentioned, we did not administer a pretest version of the cognitively-focused instrument since we discovered that the participants entered the DDSP with virtually no knowledge regarding the concepts taught by the curriculum. Thus, we used a one-group posttest only design. To obtain a better estimate of the participant's score on the underlying trait (i.e., knowledge, skill development, and problem-solving in the areas covered by the curriculum) measured by the instrument, we corrected for guessing. Since the participants did not omit any answers, a rights minus wrongs correction formula was used. Basically, this technique deprives the participant of the number of points which are estimated to have been the result of random guessing. This results in an unbiased estimate of the underlying trait, namely the participant's true score on the measure that is not a function of guessing and random chance. The following are the resulting descriptive statistics:

- The median (50^{th} percentile) proportion correct for the twelve participants was .33 or 33% correct (mean = .41, standard deviation = .20).
- The 25^{th} quartile was .27 (27% correct) and the 75^{th} was .62 (62% correct).
- The minimum score was .14 (14% correct) and the maximum score was .71 (71% correct).

Assuming that the participants entered the DDSP without any knowledge of the curriculum (an assumption we verified at the outset of the evaluation), the results of a Wilcoxon signed-ranks test indicated that *participants gained a significant amount of curriculum-related knowledge as a result of their participation in the program* ($z = -3.07$, $p < .05$). We tentatively conclude that the *DDSP fostered knowledge, skill development, and problem-solving in the areas covered by the curriculum*, as measured by our cognitive instruments.

Next, we explored the differences across the three sites by conducting pairwise comparisons of the posttest performance across the sites. Since each site completed a slightly difference instrument—with varying number of items, we used the proportion correct on the instrument as the basis of comparison. We used Mann-Whitney tests to evaluate the data.

Analysis revealed that only one of the three pairwise comparisons was significant. The *Chandler participants significantly outperformed their peers at Guadalupe in terms of* *proportion correct* on their respective cognitive posttests ($z = -1.94$, $p < .05$). The scores on the cognitive instrument were not different between J.B. Sutton and Guadalupe as well as Guadalupe and Chandler.

Program Implementation Survey

The DDSP facilitators were asked to complete a program implementation before and after implementing the curriculum. Although the participant-level data was incomplete for Sacaton, we did ask the clubhouse coordinator to respond to the survey after implementation. Table 4 captures the facilitators' responses to the twelve questions provided to them before they began working with the participants in the DDSP.

Table 8: *Responses to Program Implementation Survey **before** DDSP.*

Statements	Strongly Agree or Agree	Neutral	Strongly Disagree or Disagree	Don't Know
1. The amount of time I have in order to complete the Design and Discovery curriculum is sufficient		1 (25%)	2 (50%)	1 (25%)
2. The Design and Discovery curriculum is written at the level of a typical 5th grader.	1 (25%)		3 (75%)	
3. A typical 5th grader possesses the knowledge that the Design and Discovery curriculum assumes students have.			4 (100%)	
4. A typical 5th grader possesses knowledge well beyond what the Design and Discovery curriculum assumes.			4 (100%)	
5. I feel comfortable teaching / facilitating each one of the sessions.	1 (25%)	2 (50%)	1 (25%)	
6. I plan on seeking additional support for teaching / facilitating one or more sessions (from Intel, school, colleagues, etc).	3 (75%)	1 (25%)		
7. One or more sources of teaching support have been made available to me should I need them.		1 (25%)	3 (75%)	
8. I know where I can find teaching support or resources should I need them.	3 (75%)		1 (25%)	
9. The Design and Discovery curriculum aligns well with Arizona state standards.	2 (50%)	1 (25%)		1 (25%)
10. The Facilitator Guide is written in such a way that I can understand and use it easily.	1 (25%)	1 (25%)	2 (50%)	
11. I have extensive past experience working with students of this age group.	2 (50%)	2 (50%)		

12. My past experience includes engineering/science teaching.	2 (50%)		2 (50%)	

The facilitators' responses to statements two, three and four are conspicuous. The majority disagreed with the statement that the "[t]he Design and Discovery curriculum is written at the level of a typical 5th grader" while they were unanimous in their disagreement to the statements that "[a] typical 5th grader possesses the knowledge that the Design and Discovery curriculum assumes students have" and "[a] typical 5th grader possesses knowledge well beyond what the Design and Discovery curriculum assumes." Follow up questions determined that *the facilitators perceived that the Design and Discovery curriculum was more appropriate for children in middle school as opposed to the stated target grade level of the curriculum (fifth grade).*

After implementation, a slightly modified version of the original program survey was administered. The last two questions were dropped since these related to background knowledge, not implementation of the curriculum per se. Table 5 below captures the facilitators' responses to the ten questions provided to them after they completed the DDSP.

Table 9: *Responses to Program Implementation Survey* ***after*** *DDSP.*

Statements	Strongly Agree or Agree	Neutral	Strongly Disagree or Disagree	Don't Know
1. The amount of time I had in order to complete the Design and Discovery curriculum was sufficient		2 (50%)	2 (50%)	
2. The Design and Discovery curriculum is written at the level of a typical 5th grader.			4 (100%)	
3. A typical 5th grader possesses the knowledge that the Design and Discovery curriculum assumes students have.		1 (25%)	3 (75%)	
4. A typical 5th grader possesses knowledge well beyond what the Design and Discovery curriculum assumes.		1 (25%)	3 (75%)	
5. I felt comfortable teaching / facilitating each one of the sessions.	3 (75%)		1 (25%)	
6. I sought additional support for teaching / facilitating one or more sessions (from Intel, school, colleagues, etc).	4 (100%)			
7. One or more sources of teaching support were made available to me should I need them.	1 (25%)		3 (75%)	
8. I knew where I can find teaching support or resources should I need	4 (100%)			

them.				
9. The Design and Discovery curriculum aligns well with Arizona state standards.	2 (50%)			2 (50%)
10. The Facilitator Guide is written in such a way that I can understand and use it easily.	1 (25%)	1 (25%)	2 (50%)	

Once again, the facilitators' responses to statements two, three and four are noteworthy. At least one facilitator tempered his/her initial favorable response to the statement "[t]he Design and Discovery curriculum is written at the level of a typical 5th grader" after implementing the DDSP. After the implantation, the facilitators were either neutral or in disagreement with this set of questions. In sum, *after an opportunity to implement the curriculum, the facilitators remained convinced that that the Design and Discovery curriculum was more appropriate for children in middle school as opposed to the stated target grade level of the curriculum* (fifth grade).

Also worthwhile to point out is the variation in response to statement five across the two administrations of the survey. Before implementing the curriculum, the facilitators were relatively ambivalent in their response to the statement, "I felt comfortable teaching / facilitating each one of the sessions" whereas after implementation they generally agreed with the statement.

As a final step, we conducted a non-parametric analysis where we rank-ordered the scores for the four facilitators according to the magnitude of the change in their responses to the ten common items that appear on the before and after implementation survey before using a Wilcoxon signed-ranks test to evaluate the data. No significant differences were found in the facilitators' responses. This implies that *the facilitators' grasp of the curriculum and its implementation remained relatively stable before and after implementation*. Perhaps this could be attributed to the training program provided to the facilitators prior to their implementation of the curriculum.

Conclusions

All of our statistical findings (e.g., Mann-Whitney and Wilcoxon tests) should be considered tentative until the effects can be replicated. Without a control group, we cannot rule out multiple threats to validity. On the other hand, the descriptive statistics that emerge from our timed-interval protocol observation form are robust. The following table conveys our conclusions according to each of the three components and the particular areas of inquiry.

Table 10: *Conclusions*

Component	Area of Inquiry
Students	1. Explore whether the Design and Discovery curriculum fosters knowledge, skill development, and problem-solving in the areas covered by the curriculum. • **Finding(s):** *DDSP participants gained a significant amount of curriculum-related knowledge as a result of their participation in the program.*

	2. Document the school-age children's motivations to participate in the experience, their reactions to the experience and the science and engineering content of the curriculum, and their level of interest in pursuing related topics through future activities. • **Finding(s):** *A number of observations: (1) participants' reported interest in engineering and their self-efficacy related to engineering skills were significantly higher after participation in DDSP than before entering the program; and (2) female DDSP participants reported significantly fewer negative perceptions about engineering after participation in DDSP than before entering the program.* 3. Explore how the school-age participants (a) interact with the Design and Discovery activities, (b) progress through the curriculum in general, and (c) interact with the program facilitators around the curriculum, and (d) interact with their peers around the curriculum. • **Finding(s):** *A number of observations: (1) program participants spent the majority of their time in the program working at the whole class level; (2) one-third of program time was spent engaged in hands-on activities; (3) the most frequent type of class interaction was teacher- or facilitator-driven; (4) participants spent the majority of the time actively involved by either responding to the task/facilitator or co-constructing meaning with him or her; (5) the participants primarily demonstrated moderate to high levels of engagement throughout the entire program; (6) the major cognitive activity that we assumed occurred as a result of exposure to the curriculum was knowledge construction; (7) facilitators rarely used technology; (8) students rarely used technology; and (9) the student guide was not used the majority of the time.*
Facilitators	4. Document the implementation model used by the program facilitators. • **Finding(s):** *A number of observations: (1) the facilitators perceived that their grasp of the curriculum and its implementation remained relatively stable before and after the program; (2) formal learning settings (school) utilized the Student Guide more regularly than the informal learning settings (Clubhouses); (3) formal setting participants appeared to more frequently engage in knowledge representation than their peers participating in the informal learning environments* 5. Document educators' perceptions of young people's responses to the curriculum and of its impact on their interest in science and engineering. 1. **Finding(s):** *Facilitators observed clear signs of interest towards the curriculum on the part of students, not just in the classroom, but outside as well.* 6. Determine whether and how available resources (at the website and in print), training experiences, and/or local contextual factors support or impede program educators' (teachers or clubhouse coordinators) choices about how to implement the curriculum, and their ability to implement it effectively. • **Finding(s):** *A number of observations:* (1) *facilitators perceived that the Design and Discovery curriculum was more appropriate for children in middle school as opposed to the stated target grade level of the curriculum (fifth grade); and (2) facilitators often adapted or selectively implemented the activities in the Facilitator Guide to fit them within time constraints or to maintain student interest.*
Curriculum	7. Determine to what extent core messages and concepts are being communicated to the school-age participants.

	2. **Finding(s):** *A number of observations: (1) The participants' strong performance on the cognitive instrument and their responses to the affective instrument indicate that core messages are being communicated to students; and (2) site facilitators emphasized either the design concepts or the hands-on activities, but rarely both.*

Recommendations

Based on the results of our evaluation study, we offer several recommendations:

Table 11: *Recommendations*

1.	We recommend that Intel consider how the Design & Discovery curriculum might be adapted for a site which meets for fewer than the proposed 18 sessions, or for fewer than 2.5 hours per session. Since the three Boys & Girls Club sites we observed were unable to meet for the entire time span recommended in the curriculum, it would be wise to address this recommendation with input from facilitators and administrators from those sites.
2.	We recommend that Intel consider including explicit instructional strategies for assisting facilitators whose students are younger than the recommended age, for sites with a large number of students, or for facilitators who have limited formal teaching experience. We observed generally higher student engagement when facilitators maintained a stricter teacher-student relationship. In contrast, in sites where that relationship was less strict, students were more likely to be off task.
3.	We recommend that Intel reconsider the appropriate target age of the Design & Discovery curriculum. Feedback from site facilitators indicated that they felt the curriculum was more advanced than the 5th grade level.
4.	Alternatively, Intel might consider what portions of the curriculum could be adapted to better align with the cognitive abilities of 5th grade students. Our observations and feedback from facilitators indicate that some vocabulary is not age-appropriate, especially for English language learners.
5.	We recommend that Intel, in collaboration with the Boys & Girls Club administration, consider how the curriculum could be better delivered in an environment in which student attendance is highly irregular. Because the curriculum is designed such that sessions build upon previous sessions, a student who is absent for two or three sessions may struggle to understand more advanced concepts and activities.
6.	The facilitators used available teaching resources, and indicated that they sought out additional resources. We recommend including more such resources, both in print in the Facilitator's Guide, and online to support teachers in accessing instructional strategies, multimedia demos, and enrichment activities.
7.	Facilitators indicated that the training provided by Intel was beneficial, and data seem to indicate that some of the facilitators' success implementing the curriculum is due to their preparation during that training. We recommend Intel continue training facilitators to implement the curriculum, and, if feasible, expanding that training to reach more potential facilitators. We observed that when a site had multiple facilitators who were familiar enough to lead a session in the absence of the primary facilitator, this contributed to favorable learning conditions.

8.	We recommend that Intel investigate how the Design & Discovery curriculum might align with Arizona state standards for math and/or science. Such an alignment, in today's public education atmosphere, may greatly increase the curriculum's acceptance and value in public school settings.
9.	We recommend that Intel explore the possibility of making available kits containing all of the materials needed in order to implement the curriculum. Alternatively, the kits could be created for each session and facilitators could order kits for only the sessions they intend to implement.
10.	We recommend that Intel consider how the use of technology might be increased in teaching the curriculum to further students' exposure to examples of design concepts and interactive design activities. Increasing the use of technology does not necessarily imply increasing online content. It could be addressed by raising awareness of existing online resources, and how the technology found at the implementation sites can be used in teaching. Students and facilitators at each site appeared to be comfortable using the technology available to them.
11.	We recommend that Intel conduct an additional evaluation of the Design & Discovery curriculum implementation with a goal of validating the initial conclusions reached in the present evaluation. As has been noted, due to factors such as small sample size, the data-based statistical conclusions we have put forward are subject to validity threats. If that sample size were increased and additional data collected, more assured conclusions could be made.
12.	For future evaluations, the grain size of the observations protocols can be changed. For instance, instead of relying on timed-interval protocols at five minute increments, evaluations can rely on more protocols that capture classroom activity a single time during each session or once across the entire implementation of the curriculum. We suggest that future evaluators consult the Appalachian Technology in Education Consortium paper entitled *Classroom Observation Protocols: Potential Tools for Measuring the Impact of Technology In the Classroom* (http://www.the-atec.org/docDownload.asp?docID=31)