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Summary of Findings From the Evaluation of CryptoClub With Video Tutorials (2015–16)

Ryan Eisner

David Googins Gorsky

Jonathan Margolin, Ph.D.

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10 South Riverside Plaza, Suite 600
Chicago, IL 60606
800-356-2735 • 312-288-7600

www.air.org

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Executive Summary

CryptoClub is an academic enrichment program designed to give students opportunities to explore their interest in cryptography in informal settings. In CryptoClub, students study cryptography and learn to use mathematical knowledge and skills to encrypt, decrypt, and solve secret messages. The CryptoClub program is designed to be compatible with a range of formal and informal educational settings. For this reason, the program is modular to provide flexibility when different units are introduced. Students work their way through cipher-based puzzles from the CryptoClub website and handbook.

In 2013 the CryptoClub development team at the University of Illinois at Chicago (UIC) received a grant from the National Science Foundation's Innovative Technology Experiences for Students and Teachers (ITEST) program to design an enhancement to the CryptoClub curriculum that would support students in creating and sharing tutorial videos focusing on cryptography skills. In the video tutorial enhancement, students take the cryptography skills they learned from CryptoClub to create brief tutorial videos that explain to other students how to solve ciphers and puzzles. The goals of the tutorials program is to augment students' analytical skills by encouraging them to communicate their methods for solving the problems, as well as to build students' communication skills.

Evaluators from American Institutes for Research (AIR) conducted a developmental evaluation (Patton, 2011) of the CryptoClub video tutorials program to provide responsive feedback for ongoing program development. The following evaluation questions drove the evaluation:

1. Are students participating in the program and creating tutorials as expected? What are barriers to and facilitators of their participation?
2. What are the critical supports that students need to make high-quality cryptography tutorials that can be posted online?
3. To what extent do students enjoy participating in the video tutorials program? To what extent do they express interest in and enjoyment of cryptography?
4. What have students learned from making tutorials?
5. To what extent do other students view these tutorials? What have they have learned from watching them?
6. How effective are the summer workshop and ongoing trainings in supporting site leaders? How can support for site leaders be improved?
7. What is the quality of the tutorials that students create?

The evaluation activities during the 2015–16 school year (the second full year of implementation) focused on addressing all seven of these evaluation questions. As a part of the developmental evaluation, the evaluation team from AIR provided the project team at UIC with periodic memoranda summarizing preliminary findings from evaluation activities at implementing sites.

To answer the evaluation questions, the AIR team conducted interviews with site leaders toward the beginning of the implementation of the video tutorials program at their site. At the end of program implementation, the evaluation team conducted focus groups with participating students and administered surveys and knowledge assessments to students. Additionally, the evaluation team viewed videos of tutorials that students submitted to UIC as a part of an all-site contest.

Findings from these data sources include the following:

- Students were able to successfully create tutorial videos at five of six sites in 2015–16. Facilitators for creating tutorials included: students' previous knowledge of making videos and site leaders encouraging students to preplan and allowing them to work in groups. Barriers included: issues with video creation software; the lack of quiet, private spaces to create videos; inconsistent student attendance; and students' desire for each video to be perfect.
- Both site leaders and students said it would have been beneficial to have some example video tutorials before starting the program. Both leaders and students also said it was important to preplan before creating a video, though the support students received to engage in this process varied by site.
- A majority of students responding to the focus groups and to the survey indicated they enjoyed the tutorial-making component of the CryptoClub program. Students taking the survey indicated high interest in mathematics and cryptography; however, it is not clear if that interest was a result of their participation in the program or if they entered the club with those interests.
- Nearly all students who took a cipher knowledge assessment at the conclusion of the CryptoClub program were able to correctly answer questions related to basic substitution and Caesar ciphers. However, fewer students attempted to answer questions related to more difficult ciphers. The majority of students that did attempt the more difficult ciphers (additive, keyword, Vigenère, and multiplicative) were able to achieve full credit. These results are similar to a previous evaluation of the CryptoClub program (Margolin, Liu, Melchior, & Martin, 2014).
- Leaders at two sites stated they perceived the tutorial-creation process had deepened students' analytic abilities. These leaders explained that creating the tutorial encouraged students to think through the process of solving the cipher rather than just guessing until they got the correct answer.
- Students at two of six sites had viewed other students' videos at the time focus groups and interviews were completed. Students who had viewed others' videos reported learning new aspects about the video-making process.
- Site leaders at the summer 2015 training workshop rated the workshop as high quality, they appreciated the hands-on nature of the workshop, and they generally felt prepared to

lead the video tutorials component. Leaders said they would appreciate more opportunities to interact with one another during the course of the year.

- The 11 tutorial videos the evaluation team reviewed achieved an average of 74% of the total points on the video assessment rubric. Videos generally achieved higher scores in the domain related to their knowledge of cryptography and mathematics concepts, and they scored lower in the domain associated with their ability to teach these concepts to others.

Introduction

Overview of Program

The CryptoClub program is an academic enrichment program designed to give students opportunities to explore their interest in cryptography in informal settings. In CryptoClub, students study cryptography and learn to use mathematical knowledge and skills to encrypt, decrypt, and solve secret messages. The CryptoClub program is designed to be compatible with a range of formal and informal educational settings. For this reason, the program is modular to provide flexibility when different units are introduced. Students work their way through cipher-based puzzles from the CryptoClub website and handbook.

In 2013 the CryptoClub program received a National Science Foundation Innovative Technology Experiences for Students and Teachers (ITEST) Grant to design an enhancement to the CryptoClub's curriculum that would encourage participating students to design, create, and share brief tutorial videos. In the video tutorial component, students take the cryptography skills they learned from CryptoClub and create brief tutorial videos that explain to other students how to solve challenges and puzzles from the CryptoClub website or handbook. The goal of the tutorial program is to augment students' analytical skills by encouraging them to communicate their methods for solving the problems. Students will also build and improve upon their communication skills, especially in focusing them to communicate complex information to audiences who may know less. Additionally, the tutorial component aims to expose students to new uses of technology, especially in creating and editing videos for publication.

Over a three year grant, the CryptoClub staff from UIC began to develop the video tutorial component intended to facilitate continuous development. Development began in the 2013–14 school year with two pilot sites. Site leaders at five program sites integrated the video tutorials aspect into existing CryptoClub programs in 2014–15, and then six sites implemented the tutorials in the 2015-16 school year (two sites that had previously implemented them, as well as four new sites). This evaluation report considers the experiences of the six sites that participated in the 2015–16 school year.

Overview of Evaluation

Evaluators from AIR conducted a two-year developmental evaluation of the CryptoClub video tutorials program with the goal of providing the team at UIC with a responsive evaluation to support the development of the tutorials component (Patton, 2011). The findings from these evaluation activities were not intended to assess impact but rather to provide insight into findings from the field about aspects of the program that worked well, as well as areas in which UIC could provide additional supports. The following questions drove the evaluation:

1. Are students participating in the program and creating tutorials as expected? What are barriers to and facilitators of their participation?
2. What are the critical supports that students need to make high-quality cryptography tutorials that can be posted online?

3. To what extent do students enjoy participating in the video tutorials component of CryptoClub? To what extent do they express interest in and enjoyment of cryptography?
4. What have students learned from making tutorials?
5. To what extent do other students view these tutorials? What have they have learned from watching them?
6. How effective are the summer workshop and ongoing trainings in supporting site leaders? How can support for site leaders be improved?
7. What is the quality of the tutorials that students create?

The following sections detail the evaluation team's approach to answer these questions.

Evaluation Methods

The evaluation activities consisted of interviews with site leaders, focus groups with participating students, a survey of student attitudes toward the program and cryptography, knowledge assessments to examine the extent to which students understood specific ciphers, an examination of student video tutorials, and a survey of site leaders who attended a summer training workshop on the video tutorials component. The instruments used for these activities are modeled from the instruments used in AIR's previous evaluation work of the CryptoClub program. See Appendix A for copies of these instruments. Table 1 demonstrates the alignment between evaluation questions and evaluation activities.

Table 1. Data Collection by Evaluation Question

Evaluation Question	Leader Interviews	Student Focus Groups	Student Surveys	Workshop Surveys	Knowledge Assessments	Student Videos
1	X	X				
2	X	X				
3	X	X	X			
4	X	X			X	
5	X	X				
6	X	X		X		
7						X

As shown in Table 2, three sites participated in all four activities, two sites participated in three activities, and one site participated in only one activity.[1]

[1] Two additional sites signed on to participate in the video tutorials program, but they ultimately did not implement the program. Hence, these sites were not involved in any evaluation activities.

Table 2. Data Collection by Site

Site Name	New Site in 2015–16	Leader Interview	Student Focus Group	Student Survey and Knowledge Assessment	Student Videos
Beach Park Middle School	X	X	X	X	
Heritage Middle School	X	X	X	X	X
Jordan Catholic School	X	X		X	X
Maplebrook Elementary School		X	X	X	X
Robert Healy School		X	X	X	X
Shoesmith Elementary School	X	X			

Leader Interviews

AIR evaluators conducted semistructured phone interviews with all six site leaders who were involved in the video tutorials program in 2015–16. Phone interviews were scheduled for early in a site's implementation of the video tutorials program, and all were conducted between February and April 2016. These interviews were intended to obtain information about overall implementation of the video tutorials program at their sites (Evaluation Questions 1, 3, and 6), the challenges and barriers they and their students faced in creating the videos, the facilitators of successfully producing the tutorials (Evaluation Questions 1 and 2), and the supports that they had received or would like to receive from the staff at UIC (Evaluation Questions 2 and 6).

Evaluators then analyzed this interview data using NVivo qualitative analysis software. Evaluators inductively coded each transcript for ideas and concepts related to the evaluation question. The ideas mentioned by individuals from multiple sites were incorporated as larger themes (Denzin & Lincoln, 2003; Dey, 1993; LeCompte, 2000). Because of the limited number of sites participating in the program, an individual idea was presented as a finding if it helped explain a particular phenomenon at that site and could be important to consider as the program expands to additional sites in the future.

One evaluator analyzed the data from the interviews and a second evaluator independently assessed that analysis for quality. The findings were then organized and summarized by research question. Direct quotes from site leaders and students were incorporated when they were representative of responses as a whole or if they helped illuminate a key point.

In an effort to provide the team at UIC with actionable feedback from these interviews, the evaluation team presented a brief memo in April 2016. Additionally, the evaluation team provided informal updates about general themes from the interviews during regular check-ins conducted between February and April 2016.

Student Focus Groups

After conducting the leader interviews, the AIR staff conducted focus groups with students from four sites in April and May 2016. Site leaders were asked to help organize the focus groups and

encourage a number of students who had attended multiple sessions to participate. During the focus groups, the facilitator invited students to respond to questions related to their enjoyment of CryptoClub and the video tutorials component (Evaluation Question 3), supports they received from their leaders or other adults at their sites (Evaluation Questions 1 and 2), challenges they encountered (Evaluation Question 1), and changes that would have improved their experience. Focus groups were conducted in person and consisted from one to eight students.

Evaluators analyzed the focus group data through a process akin to the one described above for the site leader interviews.

The evaluation team provided CryptoClub staff with findings from these focus groups in June 2016 in order to inform the design of their summer 2016 site leader workshop.

Student Surveys

Site leaders helped administer a paper-and-pencil survey to students toward the conclusion of their clubs. These surveys contained items related to the following constructs (for items contained in each construct, please see the full survey instrument in Appendix A):

- Interest in mathematics (sample item: "I am interested in learning new math skills.")
- Interest in cryptography (sample item: "I would like to have a job using cryptography")
- Interest in video tutorials (sample item: "I enjoyed creating video tutorials about cryptography")

Evaluators used items from a survey administered in a previous evaluation of the CryptoClub (in 2012–13) to populate the constructs for interest in mathematics and interest in cryptography (Evaluation Question 3). The survey was also administered to sites implementing the video tutorials component in 2014–15, which allowed evaluators to examine differences across the two years.

The evaluation team analyzed sets of questions related to constructs of interest in mathematics and interest in cryptography to determine whether the responses to each set could be summarized using a single scale. There are several advantages to creating scales from groups of survey items: a good scale has better reliability and validity than a single item, it is easier to interpret than a group of items, and multiple items that measure a single construct often tap different aspects or dimensions of the construct. The evaluation team used the Rasch model for ordered categories (Andrich, 1978; Rasch, 1980; Wright & Masters, 1982) to evaluate the reliability and validity of the scales for the student survey. The interest in cryptography measure had an estimated person separation reliability of 0.85, and the interest in mathematics measure had an estimated reliability of 0.78. These indicate that each measure can consistently separate observations along the latent construct. No misfitting items in the two constructs were detected, which means that each item was indicative of the underlying construct.

Knowledge Assessments

To help determine the impact of the CryptoClub on participating students' cryptography skills (Evaluation Question 4), site leaders at impact study sites also were asked to administer a paper-and-pencil assessment of students' cryptography skills at the conclusion of their program. A total of 51 students attempted the knowledge assessment across five sites (see Table 3). This knowledge assessment was created based on items used in a previous evaluation of the CryptoClub program (in 2012–13).

For each of the eight types of ciphers covered in the CryptoClub curriculum, students were asked to use the cipher to encrypt a word and/or decrypt a coded word. To discourage cheating, each student was given one of two versions of the assessment; approximately half of the items varied between the two versions relative to whether students were asked to encrypt or decrypt a message using a particular cipher (see Appendix A for the complete instrument).

Table 3. Distribution of Student Skills Assessment and Survey Respondents by Site

Program	Surveys Completed	Assessments Completed
Site 1	24	14
Site 2	8	10
Site 3	9	7
Site 4	15	12
Site 5	11	8
Total	**67**	**51**

Students could score a maximum of 3 points on each of the 10 questions on either version, for a maximum total of 30 points. Although each question was scored using criteria specific to the cipher used, the general rubric developed by AIR and UIC used the following scoring scheme:

3 points: The task was completed with no more than one incorrect letter.

2 points: The student's work indicated an understanding of the cipher to be used, but a systematic mistake was made that caused major errors.

1 point: Most of the student's work was incorrect but there was indication of some knowledge of the cipher.

0 points: The answer indicated no understanding of the cipher.

Cipher not attempted: The student did not attempt the problem.

In order to ensure accurate scoring of the student assessments, a team of three evaluators from AIR each independently graded two thirds of the submitted assessments in a way that each assessment was examined by at least two graders. The evaluators then convened to discuss discrepancies in grades and come to agreement on a final grade.

Rating of Student Videos

Evaluators viewed a sample of student video tutorials created in the 2015–16 school year to assess the quality of their work (Evaluation Question 7). The evaluation team viewed tutorials that were submitted to UIC as a part of a year-end competition conducted by CryptoClub program staff. Participating sites were encouraged to submit up to three video tutorials showing solutions to specific problems from the CryptoClub Cipher Handbook.

Students from four sites submitted a total of 11 videos for the contest. One site submitted four videos, two sites submitted three videos, and one site submitted one video. Three sites did not submit videos to the contest.

The evaluation team assessed quality across three domains:

- Production quality
- Demonstrated cryptography and mathematics skills
- Explanatory skill.

Each domain consisted of a set of 5 to 7 indicators, which were graded on a scale of 0 through 2. The specific scoring for each indicator, as well as the full set of indicators, can be found in Appendix A. The rubric developed by AIR and UIC used the following general scoring scheme:

2 points: The behavior represented by the indicator was present throughout the video.

1 point: The behavior represented by the indicator was inconsistently present in the video.

0 points: The behavior represented by the indicator was not present in the video.

The scores for indicators within a specific domain were aggregated into a final score. Two members of the evaluation team graded each video independently using the rubric. After grading, the two evaluators discussed any discrepancies and came to agreement on a final score.

Workshop Surveys

The evaluation team administered postworkshop surveys to new site leaders attending a video tutorial training in June 2015. All six leaders who attended the training completed a survey at the end of the two-day training on how to integrate the video tutorials component into the CryptoClub. The survey contained both multiple choice (Likert) and open-ended questions that asked leaders:

- To rate the overall structure, organization, and pacing of the workshop.
- To rate their self-confidence in encrypting and decrypting the various ciphers included in the program.
- To rate the impact of the training on their ability to run a CryptoClub with video tutorials component.
- To describe (in an open-response section) how they plan to use the videos component with their students in the upcoming academic year, supports they would like to receive from the staff at UIC, and ways in which future workshops could be improved.

Evaluation Question 1. Are Students Participating in the Program and Creating Tutorials as Expected? What Are the Barriers to and Facilitators of Their Participation?

Summary of Findings

Students were able to successfully create tutorial videos at five of six sites in the 2015–16 school year. Facilitators for creating tutorials included: students' previous knowledge of making videos, encouraging students to preplan, and allowing students to work in groups. Barriers included: issues with video creation software; the lack of quiet, private spaces to create videos; inconsistent student attendance; and students' desire for each video to be perfect.

Creation of Videos

In the in 2015–16 school year, students created videos at five of six sites that implemented the video tutorials component. Eighty percent of the students who took the year-end survey reported making at least one tutorial video, and students reported making an average of 2.9 videos. However, as presented in Table 4, this average varied by site. At one site, students reported making just one video each, while students at another site made nearly five videos each.

Table 4. Number and Percentage of Students Who Report Creating Video Tutorials, and Average Number of Tutorials per Student at Five Sites

	Number of Students to Take Survey	Number of Students to Report Creating a Video Tutorial	Percent of Students to Complete a Video	Average Number of Tutorials Per Student
Site 1	24	22	91.7%	2.9
Site 2	8	8	100%	2.1
Site 3	8	4	50%	1.0
Site 4	15	8	53.3%	1.9
Site 5	11	11	100%	4.8
Total	**66**	**53**	**80.3%**	**2.9**

Note. Student survey.

Leaders at all five sites said students began making videos early in their clubs' meetings, and that they provided little instruction on the technology itself in most circumstances. As one leader said in an interview:

> I took the approach where I just let the kids jump in to using Screencast-O-Matic, and then we learned together. If one student encountered a problem, then maybe they would share it with the class and say, "Oh, hey, I figured out how to do this." Or if a student figured out how to make the cursor show up on the screen, so that they could indicate something more easily, they would just share that out with the class or with the people sitting around them. I didn't do very much direct instruction of the tool; we just started using it.

Facilitators

Students in all four focus groups said their previous experience making videos helped them make video tutorials for CryptoClub. Students at four sites had made videos for class. At two sites, students said they had experience making videos for fun. Typically, students made these other videos using a smartphone or tablet to record themselves and peers.

Students and site leaders reported a benefit from engaging in some sort of planning phase. Students at two sites said they made a script before filming, whereas students at two sites did not. Students from different sites were also split on solving the cipher before or during filming: students at three sites reported they solved the cipher before filming, but some students at one site solved the cipher as they filmed. One student said, "We presolved, so it wouldn't take as long to find the number or letter, so then we can just point it out, where the cipher is." Leaders generally encouraged students to participate in some sort of planning; as one leader pointed out, she wanted to make "sure they had done some good planning before they actually started, but without going overboard."

The structure in which students made videos also differed by site. Students at three sites either worked in pairs or groups of three to four to create videos, while students at one site worked independently. To make for an easier transition, a leader at one site paired new students with students who had previous experience in the program. Working in groups also allowed for the videos to be "more detailed and thorough."

Barriers

Both students and site leaders reported issues with the software used to create the videos. Some students reported that the software made it take longer to make the videos because of limited editing capabilities. As one student said, "If you do good in the beginning, then mess up in the middle, then you do the end. I wish you could just go to the middle, but you have to start over from the beginning, so you don't get to keep your ending." Two leaders agreed that the software was a barrier to making and editing videos and were looking for alternative programs.

One leader and students at three sites felt like the lack of quiet spaces made it difficult to complete videos. A student from one site mentioned, "The only thing that was challenging was finding a quiet space to do it in." A student from another site said, "Sometimes it's just background noise and that interferes with the recording. We have to rerecord that so it doesn't have any background interference." Site leaders were in agreement with students' statements. As one leader said, "Even with a small group, they need their space; I think that's the biggest challenge."

Leaders reported that the lack of time and inconsistent attendance also hindered students' ability to complete videos. One leader mentioned that students' attendance varied depending on other afterschool activities, which can lead to students falling behind the rest of the group on content. Another leader said there was not enough time during each session for students to complete their videos. As one leader said, "Time seems to be the big thing. They'll get started and they'll have ideas and then our club is only meeting once a week. Then we've got to go to the next week and some of this gets lost and gets started over again."

Additionally, leaders reported that students were seeking perfection at the expense of finishing a video. One leader said, “They throw out a scene or they try to redo the scene, so it's not the technology that's slowing them down. I think it's them working through their thought processes.” Another leader said students constantly redo their videos until they feel they are perfect.

Evaluation Question 2. What Are the Critical Supports That Students Need to Make High-Quality Cryptography Tutorials That Can Be Posted Online?

Summary of Findings

Both site leaders and students said it would have been beneficial to have some example video tutorials before starting the program. Both leaders and students also said it was important to preplan before creating a video, though the support students received to engage in this process varied by site.

Example Videos

Two leaders said they would like to see more examples of how to create tutorials that they could share with their students before they begin the tutorial creation process. These leaders said it would have been helpful so that both they and students knew what the tutorials should look like before getting started. "I haven't had the time to make my own so I can't give them, 'Oh, this is an example of how you can create your own,'" one leader said. "It's been kind of hard because it's been kind of them on their own, but they don't have an idea of what a tutorial should look like for cryptography." One leader suggested creating a video repository, including videos that are compatible with different computer platforms.

Students also said it would have been helpful to see example videos. Students at two sites said they would have had an easier time had they seen example videos before they started, or if there were directions on the CryptoClub website on how to create a video tutorial. They said this would be especially helpful for students who missed a session or two.

Planning Documents

Students at four sites said it was important to plan out their videos before starting to create them. However, this planning ranged from going through a formal checklist created by their site leader, to creating a detailed script, to having a general sense of what they were going to say before starting to record. However, at all of these sites, students said it was important to know how to solve the problem ahead of time. "The first thing you want to know is, you want to know the material very well," one student said.

Students Need Help With Editing

As explored in the previous section, leaders did not provide much instruction on how to use tutorial-creation technology at the beginning of their programs, and it appears students did not need much instruction. However, students at two sites said they could have used instruction on how to edit their videos. These students said their videos would have been improved if they could have edited out their mistakes, or if they could have kept a good section of their video and reshot another.

Evaluation Question 3. To What Extent Do Participating Students Enjoy Participating in the Video Tutorial Component? To What Extent Do They Express Interest in and Enjoyment of Cryptography?

Summary of Findings

A majority of students participating in the focus groups and responding to the survey indicated they enjoyed the tutorial-making component of CryptoClub. Students taking the survey indicated high interest in mathematics and cryptography; however, it is not clear if that interest was a result of their participation in the program or if they entered the club with those preferences.

Enjoyment of Video Tutorials

Approximately two thirds of students responding to the survey reported they enjoyed participating in the video tutorials component of CryptoClub. As displayed in Table 5, approximately 19% of students *strongly agreed* to the statement "I enjoyed creating video tutorials about cryptography," and an additional 48% of students *agreed* with this statement. Only 6% of students *strongly disagreed* with this statement. Additionally, more than 60% of students either *strongly agreed* (14%) or *agreed* (49%) with the statement "It was fun to teach others about how to solve ciphers."

Table 5. Students' Perceptions of Video Tutorials Component

To What Extent Do You Agree With the Following Statements?	*N*	*Strongly Disagree*	*Disagree*	*Agree*	*Strongly Agree*
I enjoyed creating video tutorials about cryptography.	67	6.0%	26.9%	47.8%	19.4%
It was fun to teach others about how to solve ciphers.	66	10.6%	27.3%	48.5%	13.6%

The survey prompted students to name their favorite part of CryptoClub as a whole. The most popular category of response to this question pertained to the creation of videos. As presented in Table 6, 22 students (38 percent) named creating the tutorial videos as their favorite aspect.

Table 6. Frequency of Responses to Open-Ended Item Asking Students to Name His or Her Favorite Part About CryptoClub (*N* = 58)

What Was Your Favorite Part About CryptoClub This Year?	*n*	Respondents
Video tutorials	22	37.9%
Learning about ciphers	20	34.5%
Solving/cracking problems	9	15.5%
Being with friends	9	15.5%

What Was Your Favorite Part About CryptoClub This Year?	*n*	Respondents
Cryptography-related games	3	5.2%
Everything	2	3.4%
Site leader	1	1.7%

These data aligns with students' reactions from the focus groups. Students in all four groups said they enjoyed participating in the video tutorials component of CryptoClub. Students at two sites said they enjoyed that the tutorials allow them to "teach" others. As an example, one student said she liked, "knowing that you're helping somebody who doesn't know how to do it." Students at another site said they might have benefitted from viewing tutorials themselves:

> Student 1: It's more fun to teach somebody to do it, not [just] learning about it.
> Student 2: And to explain your method of doing it.
> Student 3: I think it's actually easier to learn a topic from a human saying it than just a human reading it.

Students at two sites said they enjoyed the opportunity to make their own decisions and be creative as they made the videos. Students explained that they were able to make their own scripts (or not use a script), create their own animations, and present their lesson in whatever matter they liked. "[I like] being in control and not having people tell you what you can and cannot do," one student said. "You can explain it to someone, to tell them they're doing it right and not have someone constantly over your back."

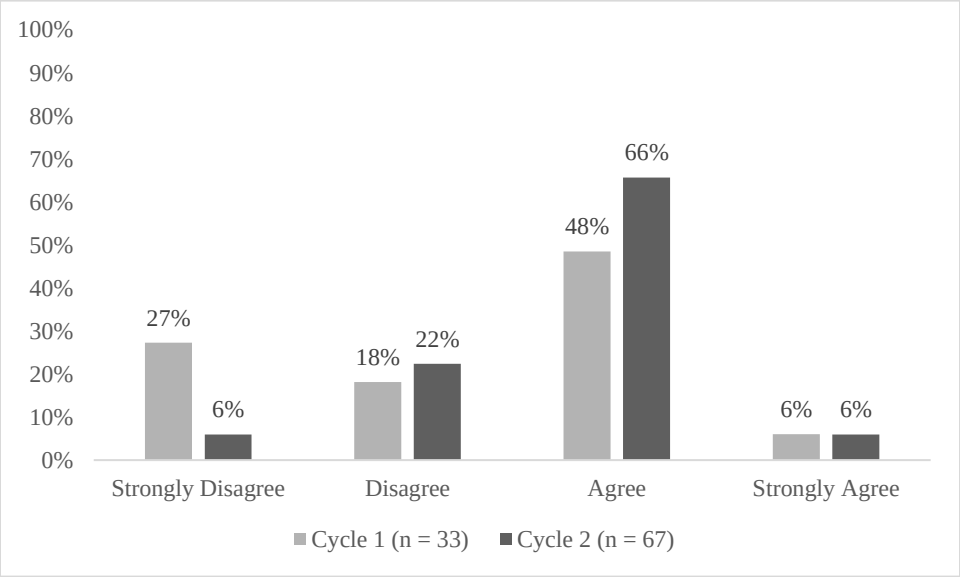
Substantiating a finding from the student focus groups, four leaders said students enjoyed the opportunity to show their creativity with the videos. However, site leaders also said students could become frustrated with the editing process or if they messed up too many times.

Interest in Cryptography and Mathematics

The evaluation team combined into a single scale score students' responses to the survey items addressing their interest in cryptography. Based on this scale score, we categorized students according to their most typical response across all the items in the scale (i.e., *strongly disagree* to *strongly agree*). The team compared students' responses on this scale to a group of students who participated in CryptoClub (with tutorials) in the 2014–15 school year to see if there were any changes over time. However, many of the sites in 2015–16 were different than the sites in 2014–15, and they might have served different students. Hence, these comparisons should be interpreted as descriptive rather than indicative of large shifts in the program.

Students showed higher levels of interest in cryptography in 2015–16 than in 2014–15. As presented in Figure 1, more than 70% of students in 2015–16 either *strongly agreed* or *agreed* with "interest in cryptography" statements, as compared with just 54% of students in the previous year. Only 6% of respondents *strongly disagreed* with these statements in 2015–16, which was less than the 27% in 2014–15.

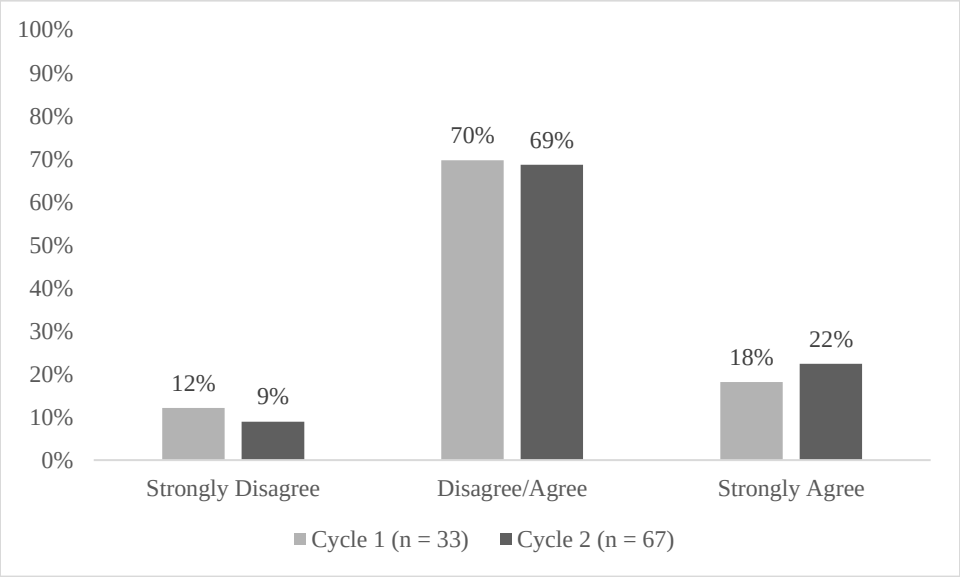
Figure 1. Student Agreement With Interest in Cryptography Items in Comparison With Previous Year's Participants



Note. Cycle 1 refers to students who participated in CryptoClub with the video tutorials component in the 2014 – 15 school year. Cycle 2 refers to students who participated n CryptoClub with the video tutorials component in the 2015 – 16 school year.

Survey respondents provided similar ratings to statements pertaining to their interest in mathematics in 2015–16 as compared with 2014–15. As shown in Figure 2, approximately 22% of respondents *strongly agreed* with statements related to interest in mathematics. This was a slightly higher percentage than those participating in 2014–15. Similarly, slightly fewer students *strongly disagreed* with these statements in 2015–16 than in 2014–15.

Figure 2. Student Agreement With Interest in Mathematics Items in Comparison With Previous Year's Students



Note. The "disagree" and "agree" categories were combined for both Year 1 and Year 2 due to the psychometric nature of this measure in Year 2.
Cycle 1 refers to students who participated in CryptoClub with the video tutorials component in the 2014 – 15 school year. Cycle 2 refers to students who participated n CryptoClub with the video tutorials component in the 2015 – 16 school year.

Evaluation Question 4. What Have Students Learned From Making Tutorials?

Overview of Findings

Nearly all students who took a cipher knowledge assessment at the conclusion of CryptoClub were able to correctly answer questions related to basic substitution and Caesar ciphers. However, fewer students attempted to answer questions related to more difficult ciphers. The majority of students who did attempt the more difficult ciphers (additive, keyword, Vigenère, and multiplicative) were able to achieve full credit. These results are similar to a previous evaluation of CryptoClub.

Leaders at two sites stated they believed the tutorial-creation process had deepened students' analytic abilities. These leaders explained that creating the tutorials forced students to think through the process of solving the cipher rather than just guessing until they got the correct answer.

Student Learning

Students who took the knowledge assessment were able to solve the questions requiring use of the easier ciphers without much apparent difficulty, but they did not attempt to solve more difficult questions requiring understanding of more challenging ciphers. The knowledge assessment asked students to solve problems related to all ciphers covered in the club's curriculum, and they were asked to both encrypt and decrypt some ciphers. As shown in Table 7, all students attempted and correctly answered the item requiring use of the substitution cipher, but only one student attempted to solve the affine cipher.

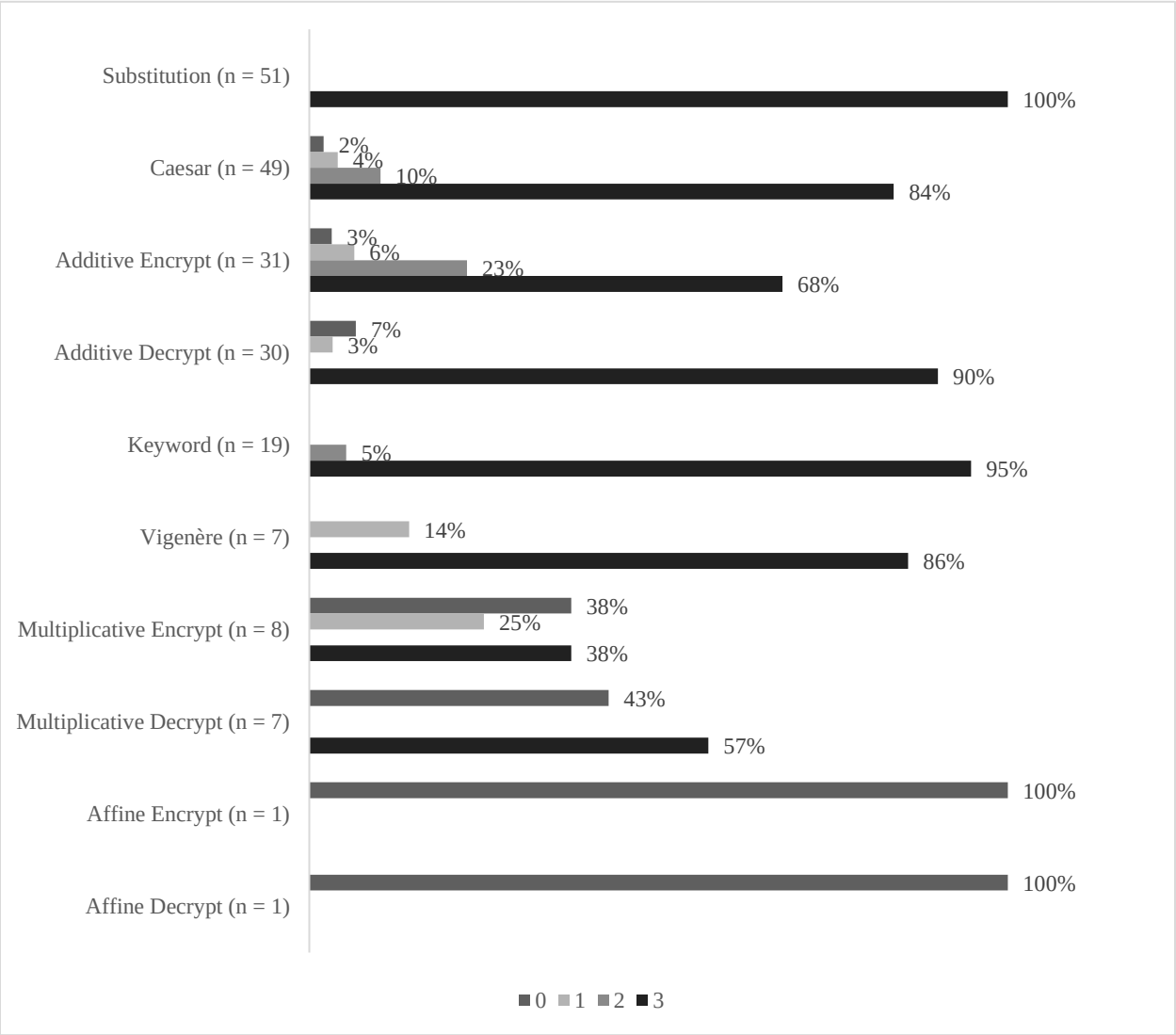
Table 7. Percentage of Students Who Attempt Each Cipher on Knowledge Assessment (*N* = 51)

Cipher	Percentage of Students to Attempt
Substitution	100%
Caesar	96.1%
Additive Encrypt	60.8%
Additive Decrypt	58.8%
Keyword	37.3%
Vigenère	13.7%
Multiplicative Encrypt	15.7%
Multiplicative Decrypt	13.7%
Affine Encrypt	2.0%
Affine Decrypt	2.0%

Students who attempted to answer a cipher generally received full credit. As shown in Figure 3, all respondents correctly solved the substitution cipher, and 84% received full credit for the Caesar cipher. However, only about 60% of students even attempted to encrypt or decrypt the additive cipher. Fewer students attempted more difficult ciphers, but they were generally able to both encrypt and decrypt the additive cipher and solve the keyword cipher. Fewer students correctly solved the multiplicative cipher, and no student correctly solved the affine cipher.

These results are comparable to a previous evaluation of the CryptoClub program (without tutorials), in which students generally scored well on basic substitution, Caesar, and additive ciphers, but did not attempt more difficult ones (Margolin, Liu, Melchior, & Martin, 2014). However, the two student populations may be very different, so it would be inappropriate to draw inferences from this comparison about the impact of the video tutorials component.

Figure 3. Student Scores on Knowledge Assessment



Perceived Impact on Students' Analytic Ability

Leaders at two sites said they believed the process of creating tutorials had deepened students' understanding of cryptography. These leaders said creating the tutorials forced students to really think through the process of getting the correct answer rather than just guessing their way through it. "What I noticed about making the tutorials that deepens their understanding is that they have to think through the steps," one leader said. The leader added, "If it's something that they just made a guess and figured out what to do, there's more expectation to explain why you did each particular step." Additionally, one leader said the process might be beneficial to students not making the tutorials, as they hear their peers explain the process to solve a cipher in words they understand. As this leader explained, "There's a student that says, 'Oh, I understand him because he used student language. Not like, teacher language'… I use a lot of academic language, which the kids are not used to."

Evaluation Question 5. To What Extent Do Other Students View These Tutorials? What Have They Have Learned From Watching Them?

Summary of Findings

Students at two of six sites had viewed other students' videos at the time focus groups and interviews were completed. The three other sites where students made videos were planning on having students show their videos to others but had not done so at the time of the interview or focus group. Students who had viewed others' videos learned more about the video-making process than content related to cryptography.

Opportunities to View Videos and Provide Feedback

Students at only two of six sites said they had viewed other students' video tutorials. One leader put videos into a shared folder on Google Drive and gave the students a chance to watch and rate them. Students rated the videos using a rubric the club created. The other leader had not made this kind of rubric.

Students at the two sites said they learned about different stylistic elements they could incorporate or avoid in their own videos. One student said she learned about different ways to present text after seeing how others had done it. Other students mentioned that they learned different organization strategies. However, at the time of the focus groups, students did not mention if they had learned more about cryptography from watching the videos.

Leaders at three sites mentioned they were planning on providing students with opportunities to give feedback on other students' videos by the end of the year. One leader was going to use the opportunity as way to prepare videos for the year-end competition, while another leader wanted to have kids provide feedback before the videos were finalized so that they could go back and make any changes.

Evaluation Question 6. How Effective Are the Summer Workshop and Ongoing Trainings in Supporting Site Leaders? How Can Support for Site Leaders Be Improved?

Overview of Findings

Site leaders at the summer 2015 training workshop rated the workshop as high quality, reported they appreciated the hands-on nature of the workshop, and felt prepared to lead the video tutorials component. Leaders said they wanted more opportunities to interact with one another during the course of the year.

Ratings of Workshop Quality

Surveys administered at the June 2015 workshop indicate that site leaders thought the two-day workshop was of high quality. As presented in Table 8, all attendees either *strongly agreed* or *agreed* with statements that the workshop was well organized, it was adequately paced, the information was presented in a clear and comprehensible manner, and the handouts and training materials were clear.

Table 8. Participants' Rating of Workshop Quality

Please Rate Your Level of Agreement With the Following Statements	*Strongly Disagree*	*Disagree*	*Agree*	*Strongly Agree*
The workshop was well organized	0	0	1	5
The workshop was appropriately paced.	0	0	2	4
The information was presented in a clear and comprehensible manner.	0	0	1	5
The handouts and training materials were clear.	0	0	0	6

Ratings of Readiness to Lead Tutorial Component

Respondents felt prepared to help students create video tutorials. As shown in Table 9, five out of six respondents either *agreed* or *strongly agreed* that they left the training with a clear understanding of how to use technology to create tutorials as well as how to lead students through the tutorial-creation process. However, the ratings to all of these items were slightly lower, with the majority of respondents selecting *agree* as opposed to *strongly agree*. Half of all attendees *strongly agreed* with the statement that they knew what a "good" tutorial looked like.

Table 9. Participants' Rating of Workshop's Impact on Readiness to Prepare Videos

Please Rate Your Level of Agreement With the Following Statements	*Strongly Disagree*	*Disagree*	*Agree*	*Strongly Agree*
I understand the technology needed to create tutorial videos.	0	1	4	1
I feel prepared to guide students through the tutorial-making process.	0	1	4	1
I have a clear understanding of the characteristics of a "good" tutorial video.	0	1	4	1

Two respondents wrote comments related to time spent at the workshop working with video-making applications. As one respondent wrote, "I got out of the workshop exactly what I thought I would: just the focus on how to make the tutorials. What I didn't expect, but appreciated, was time to work with the various programs." One respondent wrote that she would have benefitted from more hands-on time with the technology because she had a limited background in this area.

In interviews, three of five leaders reported that the training was helpful in preparing them to teach the video tutorials. Leaders said they enjoyed being able to walk through the tutorials process step-by-step with other site leaders. As one interview respondent said, "I was very pleased with the training actually, and felt that by walking through some of these things step-by-step with other teachers and then talking about what this might look like for kids in various settings really helped me think about some things I might not have thought about ahead of time."

Suggested Improvements to Training Workshop

Site leaders from both years indicated the training from UIC was effective in helping them learn how to teach students how to create tutorial videos. However, both groups suggested similar improvements to the training, namely the timing and pacing of the workshop.

As shown in Table 10, participants at the summer 2015 workshop believed appropriate amounts of time were spent on each component of the workshop. At least half of respondents said the *right amount of time* was spent on practicing with technology tools, learning about ciphers, planning individual sessions, discussing how students learn cryptography, and how to use video-making tools. Fifty percent of respondents said *too much time* was spent on planning their own CryptoClub sessions.

Table 10. Workshop Participants' Ratings of Allocation of Workshop Time

Please Rate the Appropriateness of the Amount of Time Spent on Each of the Following	Not Enough Time	Right Amount of Time	Too Much Time
Practicing with technology tools	2	4	0
Learning about ciphers	2	4	0
Planning your own CryptoClub sessions	0	3	3
Discussing how students learn cryptography	0	5	1
Discussing how to use video-making technology	1	4	1

In interviews, two leaders said they would have appreciated more time to learn how to use the technology. Respondents who reported lower levels of preparedness to lead the video tutorial component of CryptoClub also said they were less comfortable with technology generally, and they would have appreciated more time to experiment with the iPads and software. As one survey respondent wrote, "My lack of experience on an iPad made that part challenging. I felt that I needed more time with Explain Everything."

While some respondents wanted more time to cover the training material, a few respondents believed the material could have been covered more efficiently. One survey respondent said too much time was spent discussing how to use video-making technology. One interview respondent thought the training dragged at points: "I think keeping things moving … the training was probably a little bit longer than I felt like it needed to be." This leader added that two days was probably a good length for the training.

Suggested Supports for Leaders

Respondents from the summer 2015 workshop said they wanted support in forming a network with other site leaders. Four interview respondents said they found useful the regular phone calls that UIC facilitates for site leaders. One leader appreciated the feedback received on how to get kids unstuck: "Just talking about how things are going and why my kids were getting stuck on the multiplicative ciphers, what they were getting and what I could do to get them unstuck got them past that point." Another leader mentioned that it was helpful to talk with other leaders about what ciphers their sites were working on and about the video tutorials.

Participants in the summer 2015 workshop indicated on the postevent survey they would greatly appreciate the opportunity to interact with other teachers during the course of the year. Four of six respondents said they would appreciate being a part of a network of other leaders running the program. One elaborated and said it would be helpful to share tips and tricks with others going through the program.

Evaluation Question 7. What Is the Quality of the Tutorials That Students Create?

Overview of Findings

The videos that the evaluation team reviewed achieved higher scores in the domain related to their knowledge of cryptography and mathematics concepts and lower scores in the domain associated with students' ability to teach these concepts to others. Overall, students' videos achieved an average of 74% of the total points on the rubric used to assess the videos.

Overview of Submissions and Scores

Students from four sites submitted a total of 11 videos for the year-end contest. One site submitted four videos, two sites submitted three videos, and one site submitted one video. Two sites from the 2015–16 school year did not submit videos to the contest, one site because it ended its program before creating tutorial videos and one site because it had not completed videos prior to the contest submission deadline.

Students generally submitted videos about easier ciphers to the contest. As presented in Table 11, the most popular cipher was the Caesar cipher (five videos), followed by multiplicative (three videos), and additive (two videos). Only one student submitted a video about the affine cipher, and no students submitted videos about the Vigenère cipher.

Table 11. Distribution of Student Skills Assessment and Survey Respondents by Site

Cipher	Number of Videos	Percent
Caesar	5	45.5%
Multiplicative	3	27.3%
Additive	2	18.2%
Affine	1	9.1%
Total	**11**	**100**

As described in the Evaluation Methods section, evaluators rated each video with respect to three domains, using a 36-point scale. The overall score ranged from 22 to 31 points, with an average score of 26.5 out of a possible 36 points. As presented in Table 12, students received the greatest percentage of total points within the mathematic and cryptography skill domains, and the lowest percentage of points in the teaching ability domain. Sites were encouraged to submit their best videos to the contest, so it is likely the scores these videos received in this section were the "ceiling" of student work in 2015–16.

Table 12. Students' Average Score, by Domain

Domain	Average Points Received	Points Total	Percentage
Mathematics and cryptography skills	8.0	10	80.0%
Production quality	8.9	12	74.2%
Teaching ability	9.6	14	68.6%
Overall	26.5	36	73.6%

All five leaders, and students in each of the focus groups, said the level of detail students used in their videos varied greatly. As one leader explained, some students "would go straight to the answer" without explaining all of the steps leading up to the answer. "They're not really explaining themselves thoroughly enough," another leader said. This leader added, "They're just going through and doing it." Other students would present too many details in their videos. As one leader said: "I definitely think that in presenting it, I should have limited them. They want to do too much. They don't realize that it needs to be short." Students also mentioned this issue of length. One student said she recognized the videos should only be two to three minutes, but she routinely made videos that were five to seven minutes. Videos submitted to the contest were generally in the target range of three to five minutes. As presented in Table 13, six of the 11 videos submitted to the contest were in this range.

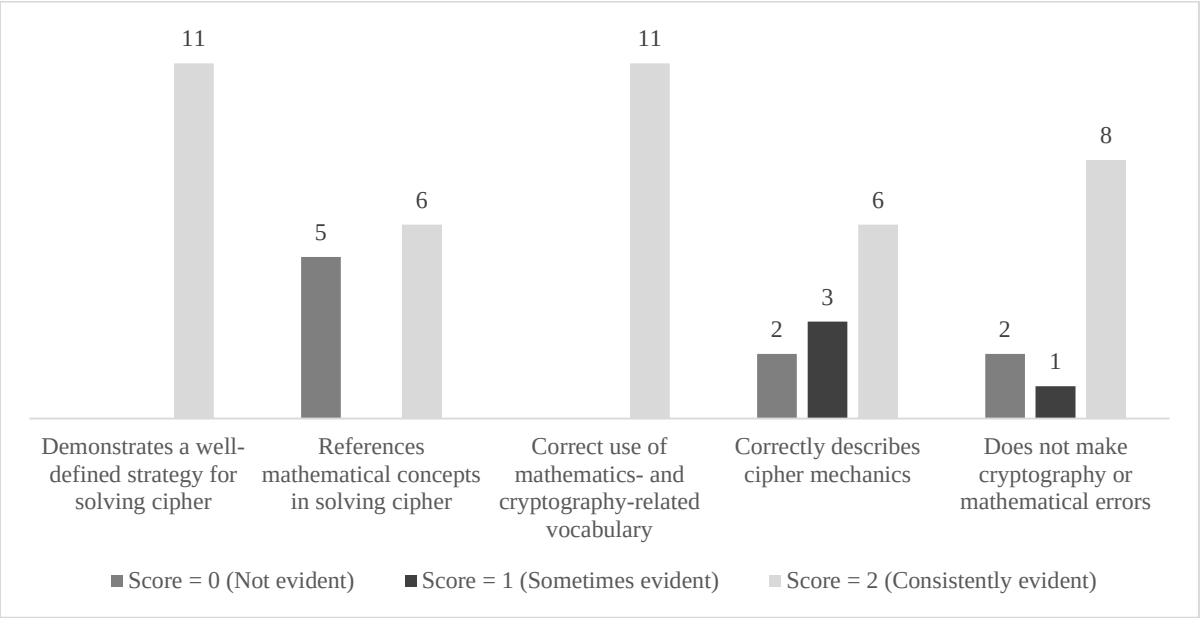
Table 13. Length of Student Video Tutorials Submitted to Contest

Domain	Number of Videos
Less than three minutes	4
Three to four minutes	3
Four to five minutes	3
More than five minutes	1

Mathematics and Cryptography Skills

Student videos received the highest scores on indicators related to mathematics and cryptography skills. Students received an average of 8 out of 10 total points on this domain. As presented in Figure 4, students demonstrated a well-defined strategy for solving the cipher in all 11 videos, and all of the videos demonstrated correct usage of vocabulary. Fewer students mentioned mathematical concepts in solving their cipher, with five of the 11 videos not referencing mathematic functions at all. Additionally, students often struggled to consistently describe the mechanics of the cipher. Students made errors in three of the 11 videos.

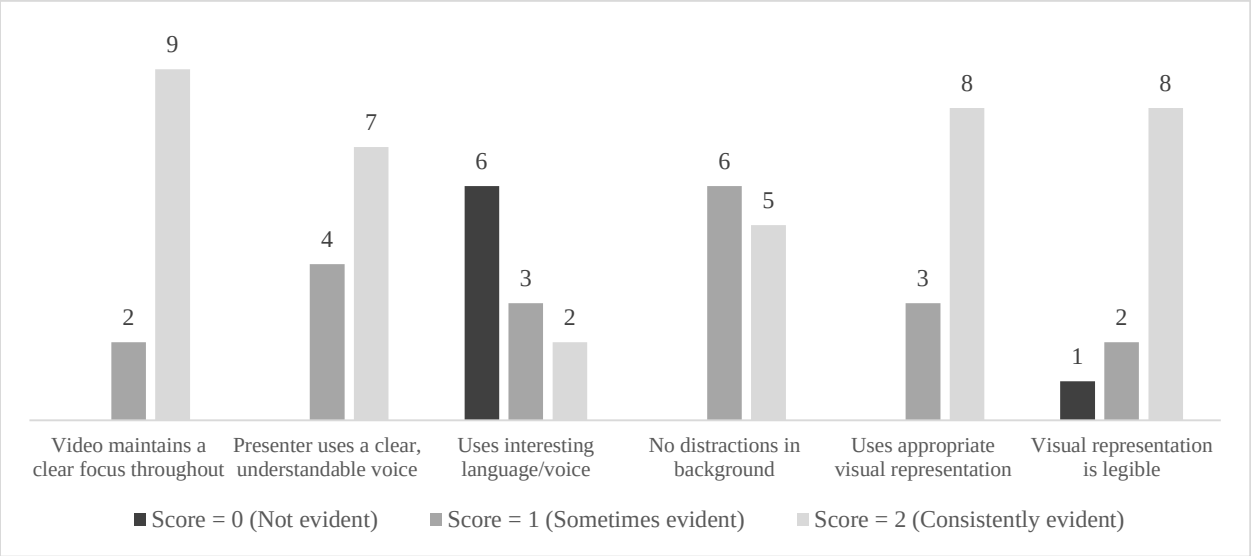
Figure 4. Student Videos' Scores on Indicators Related to Mathematics and Cryptography Skills (*N* = 11)



Production Quality

Students scored next highest on the production quality domain. Students achieved, on average, 8.9 points out of 12 on this domain. As presented in Figure 5, all videos received high scores for maintaining a clear focus throughout the tutorial, and all received high scores for using legible visuals. Students received lower scores on the indicators related to audio quality. Nearly half of the videos (five of 11) had background noise (such as other students talking, doors opening and closing). However, in none of the videos did the background noise materially distract from the tutorial. Two videos received a score of 2 for the use of interesting language or an interesting voice, and six videos received a score of 0.

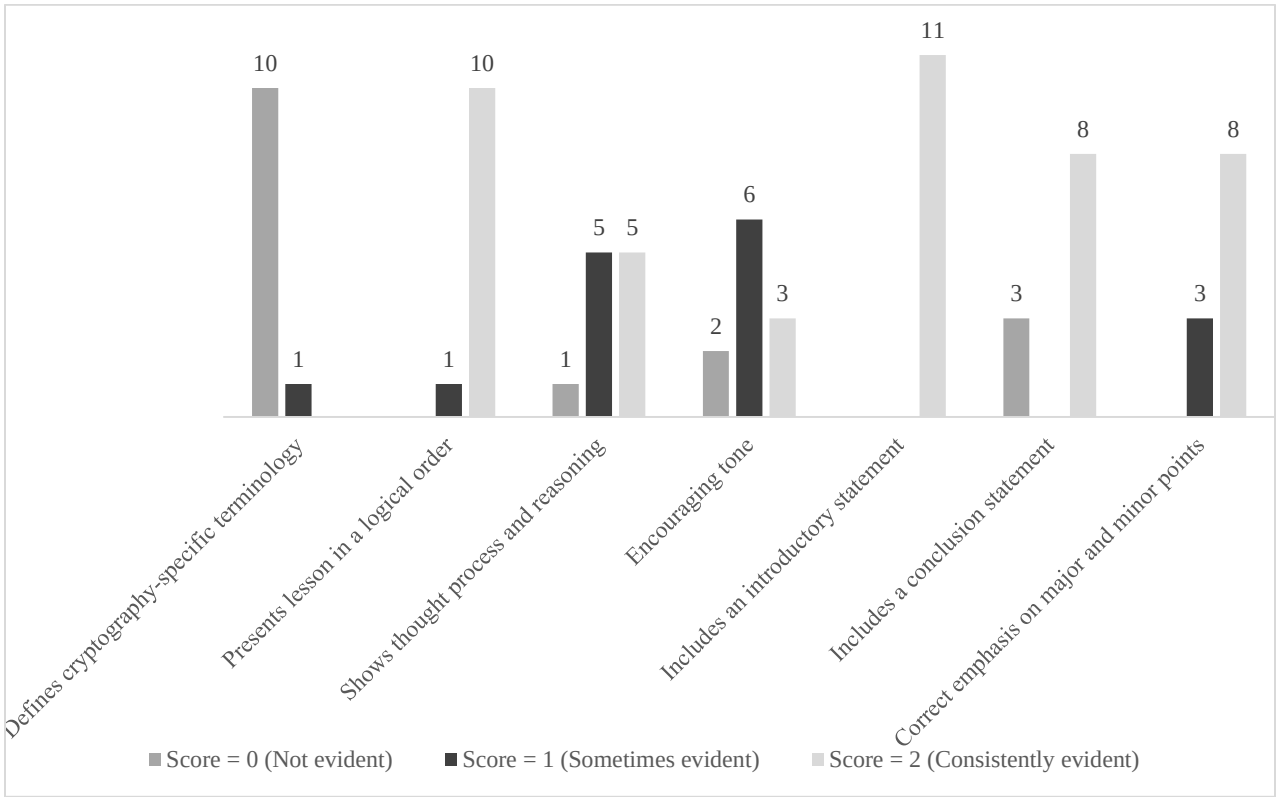
Figure 5. Student Videos' Scores on Indicators Related to Production Quality (*N* = 11)



Teaching Ability

Students scored lowest on the teaching ability domain. Students scored, on average, 9.6 points out of 14 on this domain. As presented in Figure 6, nearly all students failed to define cryptography-specific terminology in their videos (10 of 11). For example, students would use terms such as "crack" or "Mod 26" without helping the viewer understand what those terms meant. Additionally, students generally did not speak to the viewer in a way that offered encouragement. Videos varied in terms of the extent to which they explained their thought process or jumped to the next step without much explanation. Students were more successful in organizing their videos, achieving higher scores on indicators related to presenting the lesson in a logical order, including introductory and conclusion statements, and in emphasizing the proper points of their lesson.

Figure 6. Student Videos' Scores on Indicators Related to Teaching ability (*N* = 11)



Conclusions and Recommendations

Six CryptoClub sites implemented the video tutorials component in the 2015–16 school year, and students were able to create videos at five of these sites. Students created multiple videos during the course of their participation, and their videos tended to focus on easier ciphers (such as substitution and Caesar). A majority of students across sites indicated that they enjoyed creating the video tutorials, and they displayed a high interest in cryptography and mathematics on a year-end survey. Students who submitted videos to a video tutorials contest tended to exhibit strong cryptography and mathematics skills, but they often exhibited weaker teaching strategies.

Students' previous experience making videos, receiving encouragement to preplan, and being allowed to work in groups were all named as facilitators. However, sites varied in terms of the amount of preplanning in which students were able to engage. Students encountered some barriers, including the lack of private recording spaces, inconsistent attendance, and perfectionist attitudes. The majority of students said they enjoyed the tutorial-making component of the CryptoClub program, and they indicated high interests in both mathematics and cryptography. Students at few sites viewed tutorial videos, but those that did reported they learned more about the video-making process.

As a result of the findings documented in this report, AIR makes the following recommendations:

Recommendation: Expose students (and site leaders) to example videos before they begin.

Students and leaders at multiple sites said they would have benefitted from seeing example cryptography tutorial videos before getting started. Generally, students entered CryptoClub with some experience creating videos for other classes or for fun, but these videos did not necessarily align to the format of the tutorial videos. Leaders new to the video tutorials component said they did not have example videos to share with students, and they wished they had had access to videos from previous years. Example videos might have allowed students to begin making tutorials sooner or make them more quickly (and, hence, allow them to create tutorials about more challenging ciphers). Experienced site leaders should be able to show exemplar videos from the previous year to new students.

Recommendation: Encourage leaders to model or explain effective teaching strategies for students.

Of the three domains used on the rubric to assess the tutorial videos, students scored lowest on the domain related to teaching ability. Notably, very few videos defined the cryptography-specific terminology used in their videos, and only about half of the videos consistently showed the students' thought process. Students receive a greater percentage of points on the domain related to cryptography and mathematics skills, so it could have been that they viewed the videos as an opportunity to "show off" what they learned, rather than focus on explaining the problem or concept to someone who is new to cryptography. Site leaders could use example videos to model exemplary teaching strategies to participating students, or they could provide more targeted feedback to students to encourage them to practice strategies such as defining terms and mapping out the process to solve the cipher.

Recommendation: Continue to offer opportunities for leaders to network and share best practices with each other.

Four leaders mentioned that regular conference calls hosted by UIC were useful in running their programs. They mentioned that these calls helped them solve (and plan for) common challenges, as well as to learn about tips and tricks from others. Both new and experienced site leaders considered this support a positive experience; it can continue in either a formal (monthly conference call) or informal form (i.e., a listserv or social network).

Recommendation: Encourage site leaders to anticipate inconsistent attendance.

Both site leaders and students said students' inconsistent attendance at CryptoClub could hinder the tutorial-creation process. Afterschool clubs have to contend with competing afterschool activities, such as sports, plays, and other extracurricular activities. Clubs held during the school day must also contend with normal attendance patterns. If students created their videos in groups, and if a teammate was absent, then they might not be able to continue making their video or the absent teammate would miss out on the activity. Additionally, the absent student might have missed instructions about a specific cipher or the tutorial-making process. Potential solutions to address these concerns could be to encourage students to create their videos in one day and to create written or video documentation about how to create a video.

References

Andrich, D. (1978). A rating formulation for ordered response categories. *Psychometrika, 43*(4), 561–573.

Denzin, N., & Lincoln, Y. L. (2003). *Collecting and interpreting qualitative materials* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Dey, I. (1993). *Qualitative data analysis: A user-friendly guide for social scientists*. New York, NY: Routledge.

LeCompte, M. D. (2000). Analyzing qualitative data. *Theory Into Practice*, *39*(3), 146–154.

Margolin, J., Liu, F., Melchior, K., & Martin, B. (2014). *CryptoClub: Cartography and mathematics afterschool and online*. Chicago, IL: American Institutes for Research

Patton, M. Q. (2011). *Developmental evaluation: Applying complexity concepts to enhance innovation and use*. New York, NY: Guilford Press.

Rasch, G. (1980). *Probabilistic models for some intelligence and attainment tests* (Exp. ed.). Chicago, IL: University of Chicago Press.

Wright, B. D., and Masters, G. N. (1982). *Rating scale analysis: Rasch measurement.* Chicago, IL: MESA Press.

Appendix A. Protocols Used for Data-Collection Activities

CryptoClub Student Focus Group Protocol

Hello, my name is _____. The company I work for is called the American Institutes for Research. I'm here at your school to learn more about the CryptoClub Program and to gather some feedback about your experiences in the program. We want to hear about whether you liked CryptoClub, and how you made tutorial videos. We're doing this so we can tell the creators what students think to make future clubs better.

I want you to be aware that your responses will be kept confidential. That means we will not use your name in what we tell the creators of CryptoClub. That means your name will never be attached to the information new use from this conversation, and we will not identify you specifically. If you don't mind, I would like to record this focus group to make sure I do not miss anything important we discuss. The recording will not be shared with anyone else and is purely for evaluation purposes. Is this okay? *[If the answer is no, indicate that instead, you will be taking notes throughout the conversation.]* The focus group will take approximately 20 to 30 minutes, depending upon the amount of information you share.

Please introduce yourselves, telling me your name, grade and what movie you really want to see this summer.

Great—thanks for introducing yourselves! So the way this is going to work is first I'm going to ask you some general questions, then I'm going to ask you some questions about making videos for CryptoClub, and then finally I'm going to ask you some questions about CryptoClub as a whole.

Does anyone have any questions before we get started?

OK, so my first couple questions are just some background questions

Background and Cryptography

- Why did you join CryptoClub? Did you do CryptoClub before? Did you have experience with cryptography? How many sessions did you each come to this year?
- Did you make videos before making them for CryptoClub, either for fun or for class?

OK, now let's talk a little bit more about the videos you made as a part of CryptoClub

Video Tutorials

- Did you enjoy the video-making component this year? What did you like about it? What didn't you like about it?
- What was the hardest part about making tutorial videos?
- Can you walk me through the steps of making a tutorial video? (probe for technology used, instruction received from leader, instruction from peers, decision making process)

    - How do you decide what to make it about?
    - What are the planning stages?
    - How do you make the clip? Do you edit it? Do you revise?
    - How do you know when you're finished making one?
    - Did anyone help you make the videos? Your teacher? Other students in the club? Other adults?
- Tell me about a really good tutorial video someone in your club made (either by you or by someone else)?
    - Why was it good? Why was it interesting?
    - What makes a good tutorial?
    - What makes a boring tutorial?
- What is something you wish would have done differently when first starting to make the videos?

Finally, this last batch of questions is just about your general impressions of CryptoClub this year:

General Impressions of CryptoClub

- What did you like most about CryptoClub this year?
- What could make the club more interesting to students?
    - What would you do more of?
    - What would you do less of?
    - What is one thing you would you change about CryptoClub for next year?

Do you all have any other thoughts or comments about—this is your chance to have your voice heard for the evaluation!

CryptoClub Site Leader Interview

Hello, I'm _____ with the American Institutes for Research. I am part of the team that is conducting the evaluation of the CryptoClub Program. The purpose of this evaluation is to provide real-time data to UIC to help them improve the program moving forward.

Thank you for taking the time for this interview. The questions I will be asking are to find out more about how the CryptoClub program works at your site. We are particularly interested in learning more about how you have implemented the Video Tutorials program, the supports and you have received from UIC, and how the Tutorials have expanded student learning. I anticipate that it will take about 20-30 minutes.

Before we start, I just want to assure you that your responses to my questions will be completely confidential, and in our reporting of findings, respondents will not be identified. This interview is purely voluntary, and you may withdraw at any time.

I would also like to tape record our interview in order to accurately capture everything you tell me. The recording is purely for evaluation purposes and will not be shared with anyone else. We will destroy the recording after we are done using it. Do I have your permission to record this interview*?* [Note: If the respondent agrees to be taped, turn on the tape recorder and note that you need to ask again, for the record, if you have their permission to tape the interview. If the respondent wishes not to be recorded, take notes but do not proceed with recording.]

Respondent Information

1. What is your role in your organization? (e.g., teacher, afterschool program director, other)
    a. **For teachers:** What subject(s) do you teach?
2. Have you previously taught CryptoClub?
3. Did you have any experience creating video tutorials before this program?

Program Implementation

4. Please describe your CryptoClub program. To start with, in what setting does it take place?

    Probes: Meeting day, time, location, and duration

5. How many times did your CryptoClub meet? Start and end dates
6. How did the tutorials fit into the rest of the CryptoClub program?
7. How often were students engaged in making tutorial videos?

Student Characteristics

8. How many students typically attended your CryptoClub?

9. *If not addressed already:* How were students recruited into the program? Did you target certain types of students?
10. What are the grade levels of the students that attend your CryptoClub?
11. What percentage of your students had previously been a part of CryptoClub?
    a. Probe: distinguish between returning students and students new to cryptography
12. What percentage of your students made a tutorial video?

Tutorials

13. Could you walk me through the process for instructing and helping students create tutorial videos?
    a. *What ciphers would students create tutorials about? Did students get to choose their own cipher for creating the video or did you choose them?*
    b. *What technology do you use to create the videos? What file formats did you use? What were advantages and disadvantages?*
    c. *Did you already have access to this technology? If not, what process did you have to go through to obtain the technology?*
    d. *After how many meetings did students start to create tutorial videos?*
    e. *How much instruction did you have to provide students before they could begin to make videos?*
    f. *What level of detail do students go into when making the videos? What kind of mathematical content did students go into? What was the level of sophistication of the video and quality of the explanations?*
14. How many videos did students create over the course of the program? How many videos would an individual student create?
15. What process did you use to provide feedback to students about their tutorials?
16. Were there opportunities for students to provide peer feedback on others' videos? What kind of feedback did they provide?

Student Reactions

17. What did students like most about the CryptoClub tutorial videos?? What did they like least?
18. What do you think students have gained from their participation in the CryptoClub?
19. (If respondent previously taught CryptoClub without ITEST) Do you think students had a deeper understanding of cryptography after creating videos? Please explain your response.
20. Do you believe the tutorial videos enhance students' analytic skills more so than the regular CryptoClub?

Program Barriers and Facilitators

21. What have been the biggest challenges in implementing the CryptoClub Tutorials at your site?
    a. *Did you have **enough** time to work on the program?*
    b. *Did you have the appropriate facilities, in terms of space and computer equipment, technical assistance?*
    c. *Were you comfortable with teaching the tutorial video?*
    d. *Were students clear about the tasks they were expected to complete?*

Supports

22. Have other individuals helped you offer the CryptoClub and help students create tutorial videos?
    a. Who? What was their role? How did they help?
23. Did you attend the CryptoClub Tutorials training workshop?
24. Do you feel that the training you received was sufficient to prepare you for conducting CryptoClub and helping students create tutorials? Why or why not?
    a. If anything, what would you change about these trainings, if anything?
25. Did you participate in UIC's monthly follow-up calls? How useful were these calls?
26. What other supports have you received from staff at UIC? How useful have these supports been?
27. What additional supports would be helpful in future years?

Impact of CryptoClub on Site Leaders

28. Do you plan to continue to teach CryptoClub in the future? Do you plan to continue to participate in the creation of tutorial videos (either in CryptoClub or another setting)?
29. What are some ways in which the program can be improved for next school year?

Additional comments:

CryptoClub Student Survey

We would like to know more about your experience in the CryptoClub program. This survey will take less than 10 minutes to complete.

This survey is voluntary and you do not have to complete it if you do not want to. You may skip any questions that do not apply to you. You may stop the survey at any time.

We will not share your individual responses with your classmates, teachers, or principal—all your responses are confidential.

If you are willing to participate in the survey, **please write your name on the line below, tear off this sheet, and place it into the envelope that your CryptoClub leader shows you.**

CryptoClub Student Survey

I. Interest in Cryptography

To what extent do you agree with the following statements?	Strongly Disagree	Disagree	Agree	Strongly Agree
1. I think creating secret messages is fun.	❍	❍	❍	❍
2. I want to learn more about how to make secret messages.	❍	❍	❍	❍
3. I enjoy coming to CryptoClub.	❍	❍	❍	❍
4. I am interested in learning more about how to decode and crack secret messages.	❍	❍	❍	❍
5. I would like to learn more about cryptography.	❍	❍	❍	❍
6. I would like to have a job using cryptography.	❍	❍	❍	❍
7. I like looking up information on cryptography on the Internet.	❍	❍	❍	❍
8. I like working on cryptography problems even when I am not at the CryptoClub.	❍	❍	❍	❍
9. I talk to my friends about cryptography.	❍	❍	❍	❍
10. I like to read books on cryptography.	❍	❍	❍	❍

To what extent do you agree with the following statements?	Strongly Disagree	Disagree	Agree	Strongly Agree
11. I like problems, games, and puzzles that I have to think about.	❍	❍	❍	❍
12. I like problems, games, and puzzles where I have to find patterns in numbers.	❍	❍	❍	❍
13. I like problems, games, and puzzles that take me a long time to solve.	❍	❍	❍	❍
14. I enjoyed creating video tutorials about cryptography.	❍	❍	❍	❍
15. It was fun to teach others about how to solve ciphers.	❍	❍	❍	❍
16. I have used what I learned in CryptoClub to make videos in other classes.	❍	❍	❍	❍

II. Interest in Math

To what extent do you agree with the following statements?	Strongly Disagree	Disagree	Agree	Strongly Agree
17. Anyone can do math if they try.	❍	❍	❍	❍
18. Math is useful for solving everyday problems.	❍	❍	❍	❍
19. I like going to math class.	❍	❍	❍	❍
20. Math is fun.	❍	❍	❍	❍
21. I am good at math.	❍	❍	❍	❍
22. I am interested in learning new math skills.	❍	❍	❍	❍
23. Sometimes my parents and I talk about math.	❍	❍	❍	❍
24. Schools should have different types of math classes.	❍	❍	❍	❍
25. I would like to have a job where I use math someday.	❍	❍	❍	❍
26. I enjoy talking about math with my friends.	❍	❍	❍	❍

III. Favorite Part About CryptoClub

27. What was your favorite part about CryptoClub this year?

28. What was your least favorite part about CryptoClub this year?

IV. About You

29. How old are you? _____

30. What is your gender? (Please circle one.) Male Female

31. What grade are you in? _____

Thank You! We appreciate your feedback.

CryptoClub Post-Workshop Survey

Your opinion is important in measuring the success of this program. Please tell us what you think of the workshop you just completed. Your responses will remain confidential; results will be reported for the entire group, so no individuals will be identified. Your participation is completely voluntary, and you may refuse to answer any or all questions. If you have any questions, please contact Ryan Eisner by phone (312-283-2300) or e-mail (reisner@air.org).

Thank you for your time!

If you are willing to participate in the survey, please print your name on the line below. This will be used for tracking purposes only; this cover sheet will be removed from the survey when you turn it in.

Print Name:_____

CryptoClub Post-Workshop Survey

1. Please rate your level of agreement with the following statements.	Strongly Disagree	Disagree	Agree	Strongly Agree
a) The workshop was well organized.	❍	❍	❍	❍
b) The information was presented in a clear and comprehensible manner.	❍	❍	❍	❍
c) The workshop was appropriately paced.	❍	❍	❍	❍
d) The handouts and materials were clear.	❍	❍	❍	❍

2. Please rate the impact of this workshop on:	No Impact	Slight Impact	Noticeable Impact	Very Strong Impact
a) Your understanding of how to create a tutorial video.	❍	❍	❍	❍
b) Your intentions to integrate tutorial videos into a CryptoClub setting.	❍	❍	❍	❍
c) Your ability to assist students in creating tutorial videos about cryptography.	❍	❍	❍	❍

3. How confident do you feel in *encrypting or decrypt* messages using these ciphers?	Not at All Confident	Somewhat Confident	Moderately Confident	Extremely Confident
a) Caesar cipher	❍	❍	❍	❍
b) Additive cipher	❍	❍	❍	❍
c) Keyword cipher	❍	❍	❍	❍
d) Multiplicative cipher	❍	❍	❍	❍
e) Vigenère cipher	❍	❍	❍	❍
f) Affine cipher	❍	❍	❍	❍

4. How confident do you feel about *creating videos* about with these ciphers?	Not at All Confident	Somewhat Confident	Moderately Confident	Extremely Confident
a) Caesar cipher	❍	❍	❍	❍
b) Additive cipher	❍	❍	❍	❍
c) Keyword cipher	❍	❍	❍	❍
d) Multiplicative cipher	❍	❍	❍	❍
e) Vigenère cipher	❍	❍	❍	❍
f) Affine cipher	❍	❍	❍	❍

5. Please rate the appropriateness of the amount of time spent on each of the following	Not enough time	Right amount of time	Too much time
a) Practice with technology tools	❍	❍	❍
b) Learning about ciphers	❍	❍	❍
c) Planning your own session	❍	❍	❍
d) Discussing how students learn cryptography	❍	❍	❍
e) Discussing how students learn video-making technology	❍	❍	❍

6. Please rate your agreement with the following statements	Strongly Disagree	Disagree	Agree	Strongly Agree
a) I understand the technology needed to create tutorial videos	❍	❍	❍	❍
b) I feel prepared to guide students through the tutorial-making process	❍	❍	❍	❍
c) I have a clear understanding of the characteristics of a "good" tutorial video	❍	❍	❍	❍

7. What topics remain unclear to you? (Please answer below.)

8. How could this workshop be improved? (Please answer below.)

9. a. Which technologies from the workshop are you most likely to use with your students?

b. Are there any other technologies not mentioned in the workshop that you plan to use with your students?

10. What are your (or your school or organization's) goals for the CryptoClub tutorial program? In other words, what do you hope students will get out of it?

Goal #1_____

Goal #2_____

Goal #3_____

11. Which of the following best describes your role?

- ❑ Elementary teacher (grades 1–5)
- ❑ Middle school teacher (grades 6–8)
- ❑ High school teacher
- ❑ Afterschool educator
- ❑ Other (please describe) _____

12. Have you previously used cryptography as a teaching tool?

- ❑ Yes
- ❑ No

13. Have you previously used video-making as a teaching tool?

- ❑ Yes
- ❑ No

14. In what setting do you plan to lead the CryptoClub?

- ❑ Integrated within an academic class during the school day
- ❑ As an elective class during the school day
- ❑ Afterschool program at my school
- ❑ Other setting (please describe)_____

15. In what setting do you plan to have students make tutorials?

- ❑ Integrated within the regular CryptoClub
- ❑ As a separate CryptoClub
- ❑ Other (please describe) _____

16. What kind of support would be helpful to receive from UIC and CryptoClub staff over the course of the year to support your efforts?

17. Do you have any other comments about the video tutorial workshop?

Thank You! We appreciate your feedback.

Indicator	Score = 0	Score = 1	Score = 2
Production Quality			
Video maintains clear focus	Video does not maintain clear focus	Video generally maintains a clear focus	Video consistently mains clear focus throughout tutorial
Presenter uses a clear, understandable voice	It is difficult to hear presenter(s)	It is sometimes difficult to hear the presenter(s)	The presenter(s) consistently use a clear voice
Uses interesting language/affect	The presenter uses a flat tone and/or does not include interesting language (e.g., jokes, stories, metaphors).	The presenter sometimes varies their tone and/or sometimes includes interesting language	The presenter often varies their tone and/or incorporates several pieces of interesting language
No distractions in background	Many distractions in the background	Some distractions in the background, but they do not detract from presenter	No distractions in the background
Uses appropriate visual representation	Does not include many visuals to accompany explanation	Includes some visuals to accompany explanation	Consistently and appropriately maps explanation on the screen
Visual representation is legible	Can not view essential visuals during video	Can view most visuals	Can view all visuals
Cryptography and Mathematics Skill			
Demonstrates a well-defined strategy for solving cipher	Solves the cipher without a defined strategy	Uses a defined strategy to solve the cipher, but it is not necessarily correct	Correctly uses a defined strategy (e.g., looking for patterns) to solve the cipher
References mathematical concepts in solving cipher	Does not reference mathematical concepts	N/A	References appropriate mathematical concepts
Correct use of Mathematics- and Cryptography-related vocabulary	Does not use correct vocabulary	N/A	Uses vocabulary appropriately
Correctly describes cipher mechanics	Does not explain the way in which the cipher works	Does not fully explain how the cipher works	Completely describes how the cipher works
Does not make cryptography or mathematical errors	Errors throughout the video, or errors would detract from viewers' understanding	One or two mistakes are made, and they do not detract from overall understanding	No mistakes, or one minor mistake

Indicator	Score = 0	Score = 1	Score = 2
Teaching Ability			
Defines cryptography-specific terminology	Does not define cryptography-related terms	Defines some terms used in tutorial	Correctly defines all terms so the viewer can understand
Presents lesson in a logical order	The tutorial is not structured in a logical order (clear beginning, middle, and end)	The lesson is generally structured in a logical order, with only minor tangents, missed steps, or mis-orderings	The tutorial follows a logical order from beginning to middle to end
Shows thought process and reasoning	Does not explain thought process and reasoning	Sometimes explains thought process	Consistently explains thought process
Encouraging tone	Does not address the listener in an encouraging tone	Tutorial includes some encouragement to viewer	Tutorial provides multiple or consistent encouragement to viewer (e.g., use of word "you", pausing to let them solve, positive vocabulary)
Includes an introductory statement with a learning objective	No	N/A	Yes
Includes a conclusion statement	No	N/A	Yes
Correct emphasis on major and minor points	Pacing is not appropriate	Pacing is generally appropriate	Pacing is appropriate throughout

Appendix B. Detailed Results from Student Survey, Knowledge Assessment, and Rubric Grading

Results From Student Survey

Table B1. Interest in Cryptography

To what extent do you agree with the following statements?	*N*	*Strongly Disagree*	*Disagree*	*Agree*	*Strongly Agree*
I think creating secret messages is fun.	67	0.0%	11.9%	52.2%	35.8%
I want to learn more about how to make secret messages.	67	3.0%	13.4%	56.7%	26.9%
I enjoy coming to CryptoClub.	66	3.0%	7.6%	62.1%	27.3%
I am interested in learning more about how to decode and crack secret messages.	67	4.6%	15.2%	50.0%	30.3%
I would like to learn more about cryptography.	67	6.0%	22.4%	49.3%	22.4%
I would like to have a job using cryptography.	67	29.9%	52.2%	11.9%	6.0%
I like looking up information on cryptography on the Internet.	67	25.4%	44.8%	23.9%	6.0%
I like working on cryptography problems even when I am not at the CryptoClub.	67	20.9%	40.3%	34.3%	4.5%
I talk to my friends about cryptography.	67	25.4%	41.8%	28.4%	4.5%
I like to read books on cryptography.	66	25.8%	60.6%	12.1%	1.5%
I like problems, games, and puzzles that I have to think about.	65	4.6%	7.6%	50.0%	37.9%
I like problems, games, and puzzles where I have to find patterns in numbers.	67	6.2%	16.9%	52.3%	24.6%
I like problems, games, and puzzles that take me a long time to solve.	67	7.5%	29.9%	46.3%	16.4%

Note. Rows may not add to 100% due to rounding.

To what extent do you agree with the following statements?	*N*	*Strongly Disagree*	*Disagree*	*Agree*	*Strongly Agree*
I enjoyed creating video tutorials about cryptography.	67	6.0%	26.9%	47.8%	19.4%
It was fun to teach others about how to solve ciphers.	66	10.6%	27.3%	48.5%	13.6%
I have used what I learned in CryptoClub to make videos in other classes.	67	20.9%	49.3%	25.4%	4.5%

Note. Rows may not add to 100% due to rounding.

Table B2. Interest in Mathematics

To what extent do you agree with the following statements?	*N*	*Strongly Disagree*	*Disagree*	*Agree*	*Strongly Agree*
Anyone can do math if they try.	66	1.5%	3.0%	45.5%	50.0%
Math is useful for solving everyday problems.	66	0.0%	6.1%	45.5%	48.5%
I like going to math class.	67	17.9%	11.9%	40.3%	29.9%
Math is fun.	67	20.9%	16.4%	38.8%	23.9%
I am good at math.	67	7.5%	9.0%	58.2%	25.4%
I am interested in learning new math skills.	66	15.2%	9.1%	43.9%	31.8%
Sometimes my parents and I talk about math.	67	17.9%	25.4%	34.3%	22.4%
Schools should have different types of math classes.	65	15.4%	18.5%	36.9%	29.2%
I would like to have a job where I use math someday.	65	13.9%	20.0%	43.1%	23.1%
I enjoy talking about math with my friends.	64	37.5%	34.4%	18.8%	9.4%

Note. Rows may not add to 100% due to rounding.

Table B3. Impact of CryptoClub

What impact did the CryptoClub program have on:	*N*	*No Impact*	*Small Impact*	*Medium Impact*	*Big Impact*
Your interest in cryptography	66	6.1%	25.8%	53.0%	15.2%
Your interest in learning the math skills you will need	64	18.8%	15.6%	48.4%	17.2%

Note. Rows may not add to 100% due to rounding.

Table B4. Student Information (*N* = 67)

General Information	Yes	No	N/A
Did you participate in the CryptoClub program before this year?	9.0%	85.1%	6.0%

Table B5. Student Demographics (*N* = 67)

Demographics	Percentage
Gender	
Male	47.8%
Female	46.3%
Gender not identified	6.0%
Grade	
5th grade	10.4%
6th grade	43.3%
7th grade	38.8%
8th grade	3.0%
Grade not identified	4.5%
Age	
11	29.9%
12	23.9%
13	38.8%
Age not identified	7.5%

Note. Rows may not add to 100% due to rounding.

Knowledge Assessment Results

Table B6. Knowledge Assessment Results

Cipher	*N*	Score = 0	Score = 1	Score = 2	Score = 3
Substitution	51	0%	0%	0%	100%
Caesar	49	2%	4%	10%	84%
Additive Encrypt	31	3%	6%	23%	68%
Additive Decrypt	30	7%	3%	0%	90%
Keyword	19	0%	0%	5%	95%
Vigenère	7	0%	14%	0%	86%

Cipher	*N*	Score = 0	Score = 1	Score = 2	Score = 3
Multiplicative Encrypt	8	38%	25%	0%	38%
Multiplicative Decrypt	7	43%	0%	0%	57%
Affine Encrypt	1	100%	0%	0%	0%
Affine Decrypt	1	100%	0%	0%	0%

Note. Rows may not add to 100% due to rounding.

Student Tutorial Video Scores

Table B7. Tutorial Video Scores on Rubric

	Score		
	0	1	2
Mathematics and Cryptography Skills Indicators			
Demonstrates a well-defined strategy for solving cipher	0%	0%	100%
References mathematical concepts in solving cipher	45%	0%	55%
Uses mathematics- and cryptography-related vocabulary correctly	0%	0%	100%
Describes cipher mechanics correctly	18%	27%	55%
Does not make cryptography or mathematical errors	18%	9%	73%
Production Quality Indicators			
Maintains a clear focus	0%	18%	82%
Uses a clear, understandable voice	0%	36%	64%
Uses interesting language/affect	55%	27%	18%
Avoids background distractions	0%	55%	45%
Uses appropriate visual representation	0%	27%	73%
Uses visual representation	9%	18%	73%
Teaching Ability Indicators			
Defines cryptography-specific terminology	91%	0%	9%
Presents lesson in a logical order	0%	9%	91%
Shows thought process and reasoning	9%	45%	45%
Uses encouraging tone	18%	55%	27%
Includes an introductory statement	0%	0%	100%
Includes a conclusion statement	27%	0%	73%
Includes correct emphasis on major and minor points	0%	27%	73%

Note. Rows may not add to 100% due to rounding.

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