Learning Story 1: Táin Bó Cuailnge

Táin Bó Cuailnge—meaning, the Battle of the Bulls—is an epic story in Irish lore. A project around the legend was guided by Tommy Maher, a teacher in the Clontubrid National School. Clontubridis a two-teacher public school located in the parish of Lisdowney, near the town of Kilkenny. (Because of many factors, including its rural nature and its local orientation, Ireland has a heritage and continuing support for small, one-, two-, and three-teacher primary schools, located in rural areas.). Mr. Maher's class consists of a mixed age group of sixteen children, including the third through sixth classes (children nine to twelve years old).

In the Táin Bó Cuailnge legend, Medb, an ancient queen of a western province of Ireland, needs to procure a powerful bull to equal the majesty of a bull owned by her husband Ailill. She learns of a worthy bull, the Brown Bull of Cooley, and goes to war with its owner to win it. The final part of the tale recounts the fight of the two bulls when they meet.

The Brown Bull of Cooley killed the king's White-Horned Bull, impaled his body on his horns, ran around the whole country scattering parts of the bull in different places around the country, and finally collapsed and died himself. The places where the parts of the White- Horned Bull landed gave their names to that place; e.g., the Irish name for Dublin is Baile Átha Cliath (the town at the ford of the ribs). In the hands of a teacher like Mr. Maher, students learn that myths like this one often have a basis in fact. In this case, as Mr. Maher explains:

The story seems to have some loose basis in fact and to stem from folk memories of ancient actual wars between the northern and southern parts of Ireland. As cattle were, in ancient Ireland, regarded as units of currency, units in which all debts and fines could be paid. Even a murder could be forgiven by the payment of a certain number of cattle and each class of person in society had an honour price measured in cattle.

The children chose the Battle of the Bulls as the part of the Táin Bó Cuailnge to illustrate, having examined each of the seven parts of the story. In the previous year, some of the children made PowerPoint presentations of the entire tale; in their work with the Mindstorms materials, these stories were brought to life.

The children decided to build bulls from the Mindstorms materials, and initially had both bulls trying to find each other by sensing and following light. The light source was a small high powered flashlight mounted in each of the bull's heads (see Figure 1). After a lot of time and effort spent programming and testing, however, this strategy had to be abandoned as the light source was too easily corrupted (e.g., by turning on an overhead lamp or the main classroom lighting).

Another complication was that a bull would sometimes reverse too far out of range and consequently no light source could be detected by the other bull. This problem of light sources causing difficulties was a recurrent theme which the children in all classrooms involved in the project experienced at one time or another, causing them to rethink how they were going to solve the problems they encountered.

The children went about redesigning the bulls to simulate the battle. Inspiration came from another group of children in the class who had been working on building a bug which reversed when its antennae hit an object. Using this concept they built a set of horns for each of the bulls which when struck would release a touch sensor. This would cause the bull to retreat before driving forward to attack again. When building each of the bulls, great care had to be taken to ensure that both sets of horns were at the same level to facilitate the releasing of the touch sensors.

The children also decided that the victorious bull would do a victory charge around the large map of Ireland to symbolize his trip around the country. They made a large map of Ireland with holes at the places named from the bull's body parts. These place names had covered LEGO® lights behind, which were all wired back to an RCX (*the RCX is the equivalent of the LEGO® SPIKE™ hub!*). As the bulls fought they were programmed to send occasional signals back to the RCX running the lights. When this RCX received the signal it was programmed to have the lights on the map flashing on and off.

Much of the technical challenge in this project revolved around the interaction between the two bulls and the map. The children made good use of the RCX's built-in communications capability, both in the bulls' interactions, and the subsequent map display. In essence, the children designed a system that consisted of three separate yet interdependent entities, and programmed them so that a desired pattern of interaction would occur.

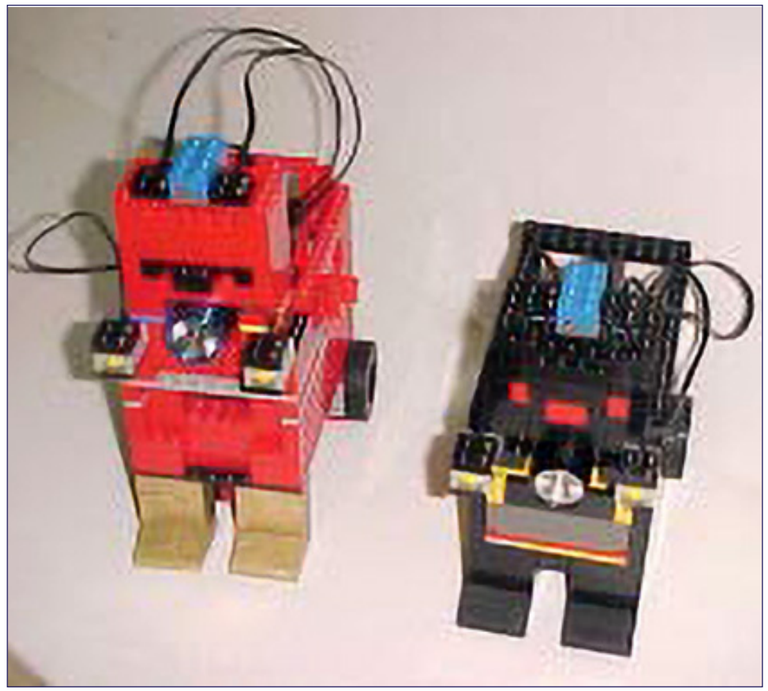


Figure 1: The Bulls of the Táin

Learning Story 2: Castletown House

The Castletown House project was led by Joan O'Rahilly, a teacher at St. Finian's National School, who had a fourth class (children aged 10 years old). St. Finian's is a medium- sized public school (approximately 220 children) located in New Castle, a suburb of Dublin. Ms. O'Rahilly's class drew inspiration from the local legend of Castletown House, a large mansion in the nearby town of Celbridge.

In the Castletown House story, hundreds of years ago the owner of the manor spent a day hunting, and while on the hunt met a handsome stranger, whom he befriended and invited back to his home. That evening, while playing cards with the stranger, the owner happened to drop a card off the table and when picking it up, noticed that his companion had cloved hooves as feet. Panic and other excitement ensued as he realized he had invited the devil into his home! A priest was sent for to exorcise the devil. The priest threw a bible, which shattered a mirror, and chased the devil into the fireplace. The devil then escaped as a puff of smoke through the chimney.

When the class decided upon the Castletown House legend as a project theme, Ms. O'Rahilly organized a series of activities to engage the imaginations of the children, and integrate this work into the life of the classroom. The class took a field trip to visit the mansion itself. While there, children took photographs of the house with the digital camera that was provided to the school as part of the project.

Back in the classroom, the children engaged in many activities to interpret the Castletown legend. They had extensive discussions, dramatic role play, storyboarding and other drawing, as well as writing up their own stories. It was the basis of classroom work for a good period of time, explored at many levels. With art materials, the children re-created features of the house, including the furnishings and portraits (Figure 2).

Figure 2: The Castletown House Model

As the central project, the class designed a miniature Castletown House of their own,which they populated with characters from the story—LEGO® models controlled by the RCX bricks (*the RCX is the equivalent of the LEGO® SPIKE™ hub!*) running programs written by the children. These actors included the lord of the manor, the devil, the priest, a maid. Figure 3 shows a child working on the devil.

The house itself also incorporated active elements, including window frames that moved up and down on their own, and flashing lights to suggest fire in the fireplace. The children conceived of a complex series of events to be enacted by the models representing the characters of the story. When they made their initial plan, they imagined each of their actors would work perfectly and predictably, but the reality was far from their ideal vision. Much of the children's learning resulted from facing the difficulties in implementing their vision.

Figure 3: The Devil of Castletown House

For example, "The Maid" would start the story by moving towards the "Corpse in the Coffin." The Corpse's RCX would be waiting for a message which would signal it to rise out of the coffin and fall back down again. A pause was built into the Maid's program which would allow for this. She would then reverse as if in fright and begin a series of beeps to signal her alarm. Then, the Corpse's RCX would in turn send a signal to the RCX controlling the windows, which would cause them to begin moving rapidly up and down to add suspense and terror to the scene. However, this could not be done as the positioning of the RCX's infrared communications port did not allow it. If the Corpse's RCX port were aimed at the Maid, then it could not also communicate with the Window's RCX brick.

As an interim measure, the children incorporated a timed wait into the program for the windows. Later, they re-sorted to manually pressing the run button to control the windows, as they were not satisfied otherwise that the windows opened and shut at the appropriate time. The central character was the devil and he presented a myriad of problems for the children. They wanted him to come into the room, stop and play cards. He was then to throw off his cape revealing who he was and when the priest arrived he was to disappear up the chimney. The children wanted to program this sequence of events with a series of timed waits, moving the devil into his required locations by using a light sensor to follow a black line.

The biggest problem was getting the Devil to follow a black line. When the children solved this, and had learned how to reset the readings for different lighting conditions, they thought they had just to program the timed waits. But once the devil was programmed to respond to the line, it always did so, even when the children wanted it to move differently. The RCX Code did not provide a way to disable and re-enable its sensor-watchers.

Collectively, this project proved quite difficult to accomplish in the manner in which it was framed. Because each character in the story relied on others to work properly, children could not choose one piece of the project and just get it to work individually; all of the actors in the story were interdependent with the others.

In subsequent work, Ms. O'Rahilly plans to guide her students toward a design with less tightly coupled sub-projects, so the small teams of children working on each piece can more readily integrate their results at the end.

Learning Story 3: The Selfish Giant

The Selfish Giant project was led by Ruth Kirwan of the City Quay National School. She had a combined second and third class (children aged 8 and 9 years old). City Quay is a public school located in the city of Dublin, and serves primarily children from economically disadvantaged backgrounds.

In Ms. Kirwan's class, the children used Oscar Wilde's story "The Selfish Giant" for inspiration. In the story, a giant owns a beautiful garden that is visited by children while the giant is away from home. When he returns, the giant evicts the children and builds a wall around the garden. From then on, it is always winter in the garden and spring never comes.
One day, the giant hears a band of musicians in his garden, but it is a single bird resting in a tree and singing a song. The bird had followed a little boy who had crawled into the garden through a crack in the wall. The giant finds the boy and lifts him into the tree, which suddenly bursts into blossom. The giant then realizes it's been forever winter in his garden because of his selfishness. He then opens his garden to the neighborhood children, and the normal cycle of seasons returns. The giant has a long and happy life, but he always misses the little boy.

One winter, the giant sees a flower in bloom and wonders how this could be. He then finds the little boy, and sees that he has the wounds of crucifixion on his hands. The giant is very upset, but the boy tells the him they are wounds of love, and invites the giant to join him in his garden in paradise. Later, the children come to play, and find the giant lying in his garden, covered with blossoms. They think he is sleeping, but soon realize he has passed away.

Figure 4: City Quay School's Selfish Giant Project

The story is especially meaningful to the City Quay children because Oscar Wilde as a child lived in the same neighborhood as the children do now, and his statue resides in the Merrion Square park which could have been the garden in the story.

Ms. Kirwan used this story as the hub for a variety of activities in her classroom. The children visited Merrion Square and saw Wilde's statue. They read the story aloud in class. The children wrote poems and short stories of their own based on the tale. And the class created a community project using the LEGO® Mindstorms materials around the story.

In the class project, four 4 ft. square pieces of pressboard were arranged in a square. On this tableau, the children re-created the central scene and characters from the story: a large garden walled off from the rest of the city, a tree in the garden, the giant, and the boy. Figure 4 shows the completed project.

The children also represented elements from their own lives in the diarama. Outside of the walls of the garden, they included the town dump, a highway filled with automobiles, and gray factory buildings. Little security cameras were interspersed throughout. A large sign on the walls protecting the garden read, "Trespassers will be prosecuted."

The children used the RCX brick (*the RCX is the equivalent of the LEGO® SPIKE™ hub!*) to program patterns of movement and beep sequences into several of the cars outside the garden walls (the rest could simply be pushed along manually). The giant was the biggest single LEGO® construction, and it included an RCX brick programmed to make its eyes flash and its arms rotated back and forth. The children also built swings and merry-go-rounds in the playground which were activated by an RCX.
None of the children had LEGO® experience coming into the school year. These were among the youngest students involved in our project. And yet, they mastered fundamental building skills, like interlocking blocks to make a strong wall, making vehicles which could steer, and they learned basic programming and control concepts.

Most importantly, the narrative project framework gave all of the children a means for self-expression. In the final result, the children collectively built a model that not only interpreted Oscar Wilde's story but also demonstrated their own personal experiences of life.

Learning Story 4: Díarmaid agus Gráinne

This classroom example illustrates how a traditional curriculum can be approached from a 21st century perspective using expressive computational materials in an interdisciplinary way while taking cognisance of the needs, interests and experiences of the learners. In keeping with the Empowering Minds community's narrative theme, the teacher and child collaborators in this example chose to work with the "Díarmaid agus Gráinne" epic in Irish folklore. This is a wonderfully varied story of love, adventure, action, pursuit and excitement, enjoyed by male and female, young and old alike. As they created their own version of this ancient Irish epic they were engaged in a variety of learning activities ranging from exploring narrative, working with building materials and problem-solving to designing, collaborating as a team and working with sensors and programming. This classroom example demonstrates effectively that these children and their teachers were active makers of their own meanings, empowered to use and shape the world with these expressive computational materials, rather than be shaped by them.

The children and their teacher chose two scenes to construct from the story, one using LEGO® Mindstorms materials with the programmable bricks and the other using clay models and the Microworlds or iMovie programming environment to create an animation. The episode I have drawn upon here is the work they engaged with using the LEGO® Mindstorms materials. Conor, the teacher kept a reflective diary during the development of the project constructions. The account details the range of materials used, the types of problems that emerged, the modifications to the story resulting from negotiations with materials and Conor's appeals to the larger Empowering Minds group for help. It also demonstrates how the project facilitated the integration of many aspects of curriculum, including heritage and culture, history, science and engineering, problem solving, writing, arts and crafts, design and construction, communication and collaboration and language development.

The following is a student's description of the scene that they had selected to illustrate from the epic as presented by the teacher in his journal: *The LEGO® scene we have chosen describes Díarmaid's escape from a fort he has built in the middle of a forest. He has built a stockade with seven doors in it around the fort. His enemy Fionn surrounds the stockade, so Díarmaid cannot escape. In our scene we want Díarmaid to walk around to each of the seven doors, pause at each one to find if there is a means of escape. At the seventh door he realises that Fionn is outside it with lots of soldiers. So Díarmaid decides to make his escape here. He actually pole-vaults out over the stockade using his spear, and lands well beyond the bank of soldiers surrounding the stockade. We want to get a good model of Díarmaid built to walk around to each door and stop, get each door to open, and finally at the seventh door get Díarmaid to escape over the stockade (Conor's diary, Feb. 2003).*

In order to enact this scene Díarmaid must be able to walk around the stockade and pole- vault out. The children's initial idea was to use a magnet to move him around and to build a crane to lift him, in order to give the impression that he was pole-vaulting out over the walls of the stockade (Figure 5). However, after many different design attempts, they discovered that their magnet idea would not work. The board they were using as the base was too thick, and even varying thicknesses of board did not solve the problem. The children then decided to embed a programmable brick within the Díarmaid model. This meant that the model was now autonomous and it could be programmed to move around as required. Previously, the children had built projects using light sensors and programmed them to follow a black line which determined the path of an autonomous robot. In their new plan for Díarmaid, he would follow a black line as he moved from door to door looking for a way out of the stockade (Figure 6).

However, this new design caused other problems. Díarmaid was now very heavy, and despite several different attempts at designing an appropriate crane, the children could not construct one capable of launching the new heavier Díarmaid out of the stockade. Now they had the problem of how Díarmaid could pole-vault away from his enemy Fionn and the awaiting army Unable to construct a scenario that remained true to the original storyline, the children and teacher discussed at length what to do. They decided to program Díarmaid to approach each door looking for Fionn, as outlined in the original story. Then he could send a signal to the door in order to open it and see what was behind it. If Fionn was waiting

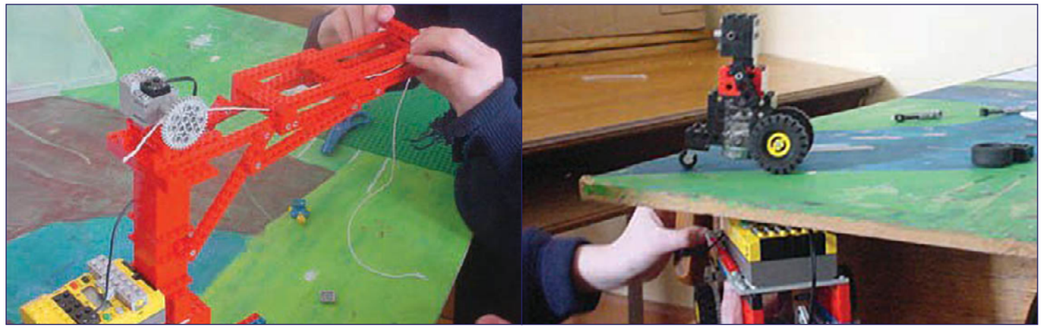


Figure 5: Building a crane to lift Diarmuid and testing the magnets to move him.

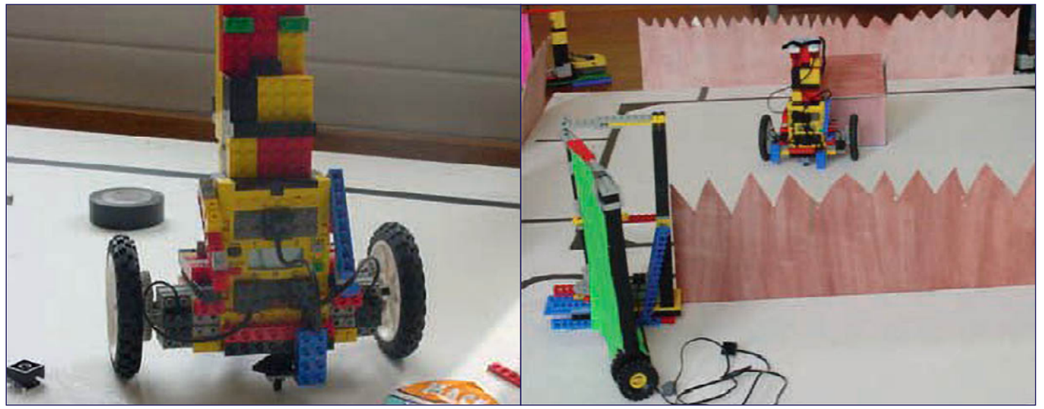
and escape was not possible he would move on and try each door in turn. This solution meant that Díarmaid needed a new program each time he moved to a new door. The original story had seven exits to the stockade. However, the brick can only store five programs at a time. After lengthy discussions and considering numerous possibilities, they decided to change the story from seven to five doors.

However, as Conor notes: *We still have a problem with getting the Díarmaid lifted out over the wall… so we'll have to use our imaginations to create a 'twist' in the story, to get him to escape in a different way. (Conor's Diary, March 2003).*

They decided that, because of their crane-building difficulties, they would take poetic license and change Díarmaid's escape strategy. He would no longer pole-vault, but would trick Fionn by faking an exit from door one and escaping through door five. Once they had made the story their own, they now had to programme their models to reflect the changes they had decided upon. The main programming elements involved getting Díarmaid to follow a black line, sending a message to each door's programmable brick, writing the programme for each door to open and ensuring that Fionn would move from gate five to gate one at the right time.

This learning story from the classroom demonstrates how the teacher and children have acquired a high level of digital fluency as they comfortably discuss and consider critically the trade-offs between the structure of the story and the computational materials they are using. Encouraged to explore and willing to spend time exploring, they tried out many different designs for their models using the computational materials. They were not constrained by the parameters of the story as they realised the limitations of the materials they were working with. This confidence in decision-making indicates deep understanding of the technology and the spirit of the project, as well as a strong sense of ownership and control.

Figure 6: Díarmaid with programmable brick (left); Díarmaid in the stockade



Learning Story 5: The Local Coalmine

This classroom example illustrates how children's learning can become more meaningful when it is informed by their local identity and then transformed by building cross-generational links and strong connections with their local community as a result of trying to solve an authentic problem.

The initial spark of the idea for this project was inspired as a result of an observation of the demographics of the local community. It happened during a conversation in class when one young child observed:

There seems to be lots of old ladies but very few old men in our local area.

Puzzled by this observation the teacher, Kathleen encouraged the children to enquire at home that evening if this observation was in fact true and if so what could be contributing to this. Upon investigation it emerged that a contributing factor to the shortage of «old men» was that there had been a coalmine in the area. Many of the miners acquired a condition called «miner's lung» and died. Encouraged by the children's natural curiosity to explore the connection between the existence of a coalmine in their locality over fifty years ago and the fact that many of them had no grandfathers, the teacher facilitated a large scale investigation about coalmining. The children consequently investigated how coal is formed, where coal mines are located, how coal is used today and in the past and read stories about life in the mines and so on.

Besides the project being a wonderful vehicle for developing cross-curricular linkage it also fostered strong cross-generational links between the school and the community as the children tried to construct a working model of the coalmine that had existed in their locality. The children's investigations sparked off much home discussion about the life and times of relatives who had worked underground. The children then began to use their information to write historical reports, fictional stories and poetry and to build their working model using the computational materials.

Groups of children were assigned different sections of the mine and asked to use their LEGO® to build a model of a mine based on the stories and information collected from their families and their research. Adult help was enlisted to create a timber cross-section of a mine tunnel so that 'coal' could be 'mined' and brought to the surface where it could then be processed by the children's machines (Kathleen's project report).

Kathleen's enthusiasm for the project was infectious and her family too were intrigued by the children's investigations and followed the project's development with interest. The timber frame for the coalmine was actually constructed by Kathleen's retired father with input from the children about the dimensions they required. In tandem with the ongoing dialogue about the project that the children were engaged in at home the various groups of builders also had to continually collaborate with each other as the building of each section of the coalmine was interrelated. The group building the «bogies» which brought the coal to the surface had to liaise with the group that was assigned the task of getting the coal from the bogies up into the sorting «hoppers». This «conveyor belt group» also needed to liaise with the «hopper building group» about the height of the proposed «hoppers» as the amount of chain available was limited and this had a bearing on the angle of elevation on the conveyor belt itself.

Two groups of girls undertook the job of building the hoppers to sort the coal. The building of towers underneath which small trains could travel was initially difficult and as the week wore on we began to wonder if two stable structures would ever emerge. The two groups eventually agreed on a design and then the negotiations over height restrictions with the conveyor builders and the coal removal group became rather involved. These two groups now had to devise a method whereby the coal could be contained in this tower and then permitted to fall through to the waiting truck. The groups eventually adapted the vertical sliding door to create a sliding trap door in the base of each tower (Kathleen's project report).

The above extract from the teacher's project report clearly demonstrates the intricacies of the design process and how each group had to closely negotiate and collaborate in order to build a complex working model of the coalmine. Their models became their "**object to think with**" as they solved each problem as it arose. The children were motivated to continue building their models despite all their setbacks and problems as they had a personal connection with the problems they were trying to solve. Each of their models went through a series of iterative designs as they refined their ideas with feedback from the other groups. Working in this manner, students get a sense of the way in which real designers go about their work, as part of a community of designers (Resnick & Ocko, 1991).

The authenticity of the overall building process was monitored regularly by the grandfather of one of the children who had worked in the local mine during his youth (Figure 7). This ongoing cross-generational collaboration further strengthened the children's personal connections with the models they were constructing and the problems they had to solve in order to incorporate the details required to construct an authentic model of the disused local coalmine.

Mr. Kealy told the children of his experiences as an adolescent working in the mine. He used their own model to explain his working day and to further describe the machines that they had built. Their initial models were built without reference to pictures of working models so it was interesting to hear how they concurred with or deviated from actual designs. He described how in one of the mines in which he worked the men were lowered down to the workface in a cage. The air-shaft was altered the next day to show a miner being lowered with his pickaxe into the mine. He also explained how when the coal came from the mine it had to be crushed. He was carefully quizzed on what a crusher might look like and the following morning a crusher was created and placed between the tunnel entrance and the conveyor belt (Figure 8). It was felt by the children that the coal would have to be swept along to reach the conveyor belt and so a mechanical sweeper was added to push the coal from underneath the crusher. This was con- nected to the RCX [programmable brick] operating the hopper trapdoors as the children felt that the same programme would work (Kathleen's project report).

On one of «the grandfather's» visits when the children were demonstrating the pulley system they had designed to bring the bogies to the surface he remarked that the original mine had in fact a double rather than a single pulley system. The children immediately wanted to reconstruct their pulley system to reflect this fact. However, this desire to reproduce an authentic working model caused a major problem for the children when they tried to reproduce a double pulley system for bringing the «bogies» laden with coal to the surface. After many attempts without success; *advice was sought from family, neighbours and the wider community ….. (Kathleen's project report).*

Figure 7: Cross-generational learning

Such was their engagement with this problem that the children and teacher voluntarily worked for many hours after school and at weekends. Finally, after much input from a range of people who called to work in the school with the children:

...the pulley problem was solved. Two strings were used instead of one continuous string and a weight attached to counteract the problem of slackening thread as two different circumferences of thread simultaneously unrolled from a single axle» (Kathleen's project report).

Further refinements were made to the model of the coalmine as a result of the children's visit to a local disused mine.

Following a meeting with Mr. Seamus Walsh, an expert on the history of mining in Castle- comer the children were taken to see a local mine. They were accompanied on this trip by Mr. Kealy, Mr. Walsh and a number of parents. They were thrilled to see the bogies still standing on their tracks, miner's hats and boots, pulley wheels and gears. They were to discover that they were a great deal heavier than their own building materials. They accompanied Mr. Walsh into the mouth of the tunnel and were not impressed with the damp and the smell. They observed the piping to remove the water from the tunnels and this was added to their model as soon as we returned to school. Following their observations of the belts and crushers all the group efforts were combined to create the seamless effect of the coal arriving at the mouth of the mine to be crushed and then sorted for sale (Kathleen's project report).

This project is an example of how learners in the Empowering Minds community are actively determining their own goals rather than functioning passively in the classroom. This learning by doing is much more meaningful than rote learning or reading about something at second hand. These children were driven by their own sense of wonder, had ownership of their learning agenda and actively constructed knowledge for themselves. This pursuit of personally set learning goals suggests that when students take ownership of knowledge instead of relying solely on teachers or textbooks, they are dedicated to constructing and building knowledge rather than merely receiving and reprocessing it.

Figure 8: Crusher on the right with a conveyor belt taking the coal over to the main conveyor belt where it is being taken up to the sorting towers. The programmable bricks have been enclosed in a different coloured casing for easy identification by the different groups.