The Fairground Ride

Abstract
Fairgrounds are a popular topic both at Key Stage 2 and 3. It is a context which is familiar to many children from first hand experience and there are a number of useful videos and printed materials which support work in this area. The children are able to produce models which move in a variety of ways, which they find stimulating. The introduction of the project to a class of Year 8 children in a Forces school in Germany is discussed and details given of appropriate FPTs (Focused Practical Tasks) and IDEAs (Investigative, Disassembly and Evaluative Activities) which were carried out. Finishing techniques were trialled and evaluated to ensure a quality finish. Throughout, the evaluation of the project draws out some useful pointers for those who intend to carry out the project themselves.

Introduction
The impetus for this topic came after undertaking a fairground project with Year 6 classes. Simultaneously, DATA produced a similar topic intended for Years 5 / 6 of 8 weeks duration. In theory, all should have been well! However, after a couple of years teaching this topic to Year 6 the following problems came to light:

- As the school's scheme of work for technology tended to have strong links with other curriculum areas, a change of emphasis was thought due for Year 6. With the development of the 'Victorians' in humanities, the year co-ordinator requested that I consider the design and construction of Victorian pull-along toys.

- I had generally felt that the mechanisms best suited to fairground rides were too complex for construction by Year 6 pupils. As considerable speed reduction and high torque was required from an electric-motor drive, a worm-drive seemed to present one of the most effective gear systems. Such a drive was thought beyond the capabilities of the lower ability members of the year group.

- The scope of the project suggested a longer topic length than the one timetabled for Year 6 and would require reasonable tenacity and patience to ensure Desirable Outcomes.

- The previous Year 8 topic of building-site machines had run for a number of years but did not sufficiently stretch the more able children. It had also found greater accord with boys than it had girls. First-hand experiences were also 'drying up'. The local building sites were becoming few and far between as conveniently accessible houses were nearing completion. The building boom in Germany was coming to an end!

All of these factors led to a migration of the fairground ride from Year 6 to Year 8. A two year break in the use of the topic avoided repetition for pupils who had already encountered it in Year 6. In utilising the topic at Key Stage 3, a number of planning tasks had to be negotiated first. These consisted of the following:

- The skills and knowledge development of the pupils had to be checked against a departmental audit that was taking place and the long-term plan revised. Ideas for likely progression were noted and an outline plan produced (see Figure 1).

- The Key Stage 2 type DATA plan had to be converted and upgraded to a Key Stage 3 layout in terms of format and content (see Figure 2).

- Guidance and resource materials had to be produced for the pupils.

- Assessment instruments were to be devised in order to give a more detailed profile of attainment than was thought necessary for Key Stage 2 use.

- A simple system had to be devised for producing worm-drive or compound-geared gear-boxes. To work effectively, these had to be accurately produced by all ability groups, ensuring that gears meshed smoothly. This would be particularly diffcult to ensure in the case of worm gears where the axis of the worm would lie on a different plane from the axis of the worm wheel. Some form of adjustment would prove beneficial!

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Figure 1 Probable lines of progression: mechanisms

Use made of two pulleys → Lay-shaft pulley /Simple gear train → Compound gear train → Bevel-gears and worm wheel

- Higher ability groups may also calculate velocity of final shaft given motor speed of, say, 3000r.p.m.
- Higher ability groups may include mechanisms incorporating cams or cranks to add to available movements.
- At the end of the topic, groups could power the completed ride from a computer interface.
- The interface may be used to run decorative lights in addition to the above routine.
- Various forms of switch may be included to control decorative lights.
- Control routines may be developed to include a feedback component such as a 'coin in the slot' start to the ride.

Planning outline

- Initial research. Trip to a 'Kirmes' or theme park.
- IDEAs: Existing mechanisms examined e.g. old sewing machine, battery operated toys, small electrical or mechanical kitchen appliances or video tape-decks.
- FPT: Lego or similar used to experience range of mechanisms that may be of use.
- Initial design sketches.
- Construction kits used to trial possible mechanisms. Speeds ascertained by observation, use of rev' counter or calculation.
- Match construction kit components to consumable components.
- Build gearbox.
- 'Size' rest of ride ... produce working sketches or drawings.
- Plan construction.
- Make it!

Figure 2 Fairgrounds

Materials focus

Control technology.

Potential outcomes

Fairground ride controlled by Lego lines program.

Resources

Assorted gear wheels, card, lOmm x lOmm wooden strip, 'corriflute', 6mm MDF squares lOOmm x lOOmm, lOmm dowelling cut to 32mm long, lOOmm strips of 2Omm x lOmm softwood; 4mm steel axles, 4mm intemal diameter PVC tube, 5mm MDF offcuts.

Investigative, disassembly & evaluative activities (IDEAs)

Examine existing mechanisms, e.g.: battery powered toys; video-player drives; small electrical household appliances.

Focused practical tasks (FPTs)

Construct Lego technic models to demonstrate venous drive systems that could be of assistance.

Extension activities

- Use reed switches to operate lights.
- Use cam-operated auxiliary mechanism.
- Use computer procedure incorporating feedback. This could take the form of coin-operated rides.

Project Planning

From previous experience, it was anticipated that a period of 10–11 weeks would be necessary to complete the perceived outcomes. In order to produce a 'rounded' experience and provide links to other areas of knowledge, preliminary, or introductory tasks were undertaken during a previous term and follow-up activities in the subsequent term. As may be seen from the long term plan, the Autumn term was used to introduce more formalised isometric and orthographic drawing skills in the context of a topic on pneumatics. Following this, 'Lego-technic' was used to construct basic fairground rides using some typical gearing arrangements. These may be viewed as progressing in complexity as indicated below:

> Simple spur gears → Compound gear-trains → Bevel/mitre gears and crown-wheel & pinion → Worm and worm wheels

Opportunity existed to differentiate this progression further as children of higher ability were tasked with calculating output speeds and determining ratios. Lower ability groups were able to monitor the increase in output torque in the various systems by direct experience, and measure output speeds using a hand-held tachometer. Discrepancies between motor speed and output shaft speeds gave rise to discussions about frictional losses and the use of bearings (this coincided with work being done in Science regarding forces). To reinforce the group's appreciation of gear systems, redundant household appliances were used as illustrations. These included hand-whisks, food mixers and audio cassette drives to show the more basic systems, and video-cassette drives to demonstrate complex gearing using compound gear-trains and worm-drives. Once removed from the video recorder, these drives may be connected to a 6v battery to demonstrate their operation. The intriguing functioning of these devices will induce most children to study their operation in depth, given the opportunity.

During this first term, a visit to a local theme park was planned. It was decided that Year 8 would accompany Year 4 children and question them regarding their opinion of particular rides (consumer survey). Unfortunately, a bout of illness postponed this exercise. Further to this activity, the group were asked to plan a typical theme park and suggest a suitable site on an Ordnance Survey map. This not only gave rise to cross-curricular links with geography and art but also developed a good understanding of scale and the ability to devise a detailed specification list. The latter is a task that usually gives rise to a limited range of responses but in this instance opened up opportunities for extensive lists of relevant design criteria.

It is intended that the children plan their own work; firstly on a daily basis and, secondly, within a six-week block. A teaching plan was obviously essential to maintain an overview of the topic (see Figure 3).

The Summer term saw the completed ride being used as one component of a control technology course. For the purposes of this assignment, detailing of these aspects of the control technology course have been omitted, but likely outcomes are mentioned in Figure 2.

Project planning: evaluation

Due to a number of factors, slippage occurred within the 10 week programme. Much of this could be offset by the odd lunchtime set aside for the children to work in the Technology Room. On reflection however, 12 weeks would seem a more realistic time-frame. These additional weeks would be used to support the construction phase of the work.

Inevitably, some projects tended to evolve into more complex designs than others, and the use of the odd lunchtime proved to be a very successful way of restoring the status quo. The only problem accompanying this option, (apart from my not being able to put my feet up!), was the situation that all of the group wished to press on ... not merely those who were lagging behind due to a slightly greater work-load.

During the initial design stages, some well detailed sketches were produced but unfortunately, much discussion proved

Figure 3: Theme park ride: module plan

Theme Park Ride: Module Plan

Week	Class work	Resources	Homework
1	▪ Introduce topic: View video;discuss experiences of theme parks. ▪ Introduce idea of brainstorming and start listing ideas. ▪ Visit to theme park discussed.	Video: 'Techno' - Theme park clip. Theme park slides and photographs. Visit outline / parental consent letters. A3 paper.	Discuss ideas at home and / or with others and complete brain-storming sheet.
2	Produce range of ideas. Discuss use of colour, auxilliary views and annotation.	A4 / A3 drawing paper. Examples of auxiliary views from technical illustrations.	Initial design ideas drawn on A4 and A3 paper. Annotation added.
3	'Lego-tecnic' models: ▪ Pulleys ▪ Simple gear trains ▪ Compound gearing / Lay-shafts ▪ Bevel-gears / Crown-wheel & pinion ▪ Use of worm-drive / wheel	1031 / 1032 'Lego-technic' sets. Examples of gearboxes in everyday items such as drills, whisks, food mixers, clocks, video and tape decks etc. Photos on back of 'Lego' work-cards.	Further design ideas drawn on A4 and A3 paper. HAG's add auxiliary views.
4	Orthographic drawings produced for 'Lego-technic' models produced last session.	A3 plain paper / graph paper. Isometric drawings or pictures of 'Lego - technic' models. 6-week planning sheets.	'Lego-technic' orthographic drawings.
	▪ Orthographic drawing quiz. ▪ Discuss other forms of graphic representation.	Orthographic quiz sheets A & B and answer sheets. Examples of isometric and oblique drawing.	
5	Produce 'Lego-technic' prototype of theme-park ride. Add card components to mirror desired effect.	Card, bifurcated paper fasteners, 'Blue - Tac'.	Draw suitable mechanism for theme park. Annotate and dimension.
6	Produce card model of theme park ride to provide a basis for discussion regard- ing size, construction and functions.	Card, long-arm stapler, cellotape, double-sided advesive tape, cardboard tube, lolly sticks, card discs, fasteners.	Designs for design folder considered. Pupils with access to DTP package and clip-art to produce final copy
7	Drill gearbox plates, fit spacers and ascertain drive-shaft positions.	6mm MDF squares, 10 mm dowel, 4mm I/D plastic tube, 4mm steel rods, gears, set up drilling machines and jigs. Computers with clip-art / DTP package.	Draft copy of 6-week planner produced.
8	▪ Discuss marking-out and cutting of strip and sheet materials. Make structures required to give form to ride. ▪ Discuss bush bearings, positioning of gears, cams and linkages and ways of producing similar components. ▪ Complete gearboxes.	Strip and sheet wood and plastics, assorted dowel rod, foam-board, 'corroflute', 4mm steel rods, assorted gears, 'Mod-roc', Plaster of Paris, papier-mâché, motors and mounts, assorted machine screws and nuts, assorted washers, assorted wood -screws, wooden beads, cotton reels.	6-week planner refined following discussion. HAG's to produce cutting lists if planner OK.
9	▪ Assemble sub-structures. ▪ Add 'embellishments'. ▪ Test and refine action.		Revisions drawn / noted. Design folio organised. (Optional circuit diagrams pro -duced)
10			Evaluation exercises.
	▪ Begin painting. Finish during 'club-time'. ▪ Add electrics.	Acrylic / polymer paints. Wire, bulbs, bulb -holders, LED's, resistors, battery packs, switches, snap connectors.	

CURRICULUM DEVELOPMENT

necessary before satisfactory annotation occurred. This was particularly the case regarding the overall function of the ride as many pupils regarded it as common sense as to how the ride ultimately performed. It was assumed that everyone had experienced a ride such as the one illustrated and indeed, most of the group had been fortunate enough to have visited at least one theme park during their time in this country. Furthermore, initial discussion remedied any lacking knowledge as experiences were readily exchanged and compared. As some of the design sketches developed, many of the lesser able pupils were reluctant to mix 'pidorial' views with those illustrating gearboxes or related mechanisms or components. The notion of 'opening-up' such a drawing with a sectional or cut-away view was thought 'destructive' and most pupils preferred to produce separate illustrations to maintain 'purity'. During future projects I will probably introduce drawing tasks that familiarise the children with the concept of combined drawings in an attempt to redefine a 'drawing culture'.

The use of 'Lego-technic' to familiarise the pupils with suitable mechanisms and then producing a prototype or mock-up proved very successful. It was soon witnessed that certain elements of the mechanisms previously constructed were used 'en-bloc' to create the drive-train for the chosen design proposal. Lego work-cards were filed together in a ring-binder and children were encouraged to browse through the pages in order to find a mechanism perceived to perform in a similar fashion to their chosen ride where the desired action could not be satisfied by one of the mechanisms already covered. Slight adjustments to monitor speed and movements were easily and quickly made before consumable components were selected to perform the same function. A display board was set up to illustrate the consumable components that mirrored their 'Lego-technic' counterparts. Previous experience of mechanisms in the Autumn Term ensured that the majority of the children matched components by the number of teeth rather than external diameter. This underlined the success of the initial FPTs.

The progression from one type of gear system to another appeared logical to the children and all but the less able appeared capable of combining or refining the systems covered. The notion of a worm-drive only being able to impart its drive from worm to worm wheel continued to confuse many, however, until quite late on. First hand experience of trying to twist the system in both modes eventually won the day! Conversely, the notion of a worm having only effectively one tooth appeared to be immediately understood.

Although the study of household appliances incorporating gears, helped the understanding of basic gear systems, its later transfer to fairground rides appeared too remote and abstract. Here it was found more benefcial to refer to gearing systems in their Lego-like form. Children were quick to identify worm gears, pulley drives, cams and compound gear trains in, for example, video cassette transport systems proving this to be a useful learning exercise in its own right.

Daily targeting sheets became a useful method by which short term planning could be approached. The writing frames contained on the sheet helped spread the workload between three tasks. These were to be completed before work was to begin, at the end of the session and, possibly as a point of reflection as part of the homework session. Once the pupils underwent a few sessions giving a detailed plan of the 90 minutes working time for each session, six week planning grids were drafted, discussed and written up in their final form. This task was certainly perceived as taxing by the less able pupils who, on reflection, would have been best allowed to continue with either daily target sheets or tasked with completing two weeks of a six week planner at a time. Certainly, for all members of the group, discussion proved necessary before the planning sheets listed satisfactory detail. All too often, bland, all encompassing statements were made that were of little practical use. This exercise probably proved the least motivating, most demanding part of the project but ultimately proved to be the most useful in terms of preparing the children for individual working. This type of work is therefore to be included in Year 7 in order to provide pupils with the necessary

practice and experience. Visualising skills could also be fostered by a technological form of 'scripted fantasy', whereby simple tasks may be envisaged step by step before committing to paper. Flow diagrams of simple sequencing tasks may also be worthy of investigation in the future.

Gearbox construction

The gearbox component of this project was potentially the aspect of the work that would permit practical success or contribute most to mechanical failure. A whole wealth of commercial gearing components are now available from numerous suppliers, many of which share similar tooth forms, enabling the components to be interchanged with one another. The commonest axle size appears to be 4mm, suggesting the use of 4mm steel rod if the task is not to be further complicated by boring out components to fit wooden dowel rod of 5 or 6 mm diameter. Due to this standard axle size, plastic tubing of 6mm outside diameter and 4.1 mm internal diameter was used to provide a low-friction / low-wear bush. The ease of drilling MDF board to high degrees of accuracy, suggested also that this should be used to form the plates of the suggested gear-box.

Providing the pupils with a basic box-form not only ensured a greater degree of success in constructing the gear-box, but also enabled the children to concentrate on the other, more important, aspects of the project. Simultaneously it enabled close monitoring of the initial stages of construction and took the group through basic techniques that would transfer to other stages of construction. Useful FPTs were therefore covered whilst constructing this essential part of every fairground ride. (These techniques covered marking out of strip and sheet material, sawing strip wood, drilling holes using hand-drills and the drilling machine, using wood screws, sawing metal rod and plastic tubes, working components in pairs and constructing basic forms using dowel rod.)

A drilling jig was used to drill the corner holes for 10 mm dowel. As the side members (which may be used to carry the worm axle bearings) can slide between the front and back plates and are guided further by the sides of the dowel rod, simple sliding of these members can ensure the best possible meshing of worm and worm wheel. The whole assembly is secured with wood screws passing through the side plates into the wooden, sliding strips. Basic instruction is necessary to help the positioning of worm wheel holes or decide the positions of meshing spur gears. In the case of the latter system, it is easier to position one hole, temporarily hold one of the meshing gears in place with a short piece of axle rod, then position the second meshing gear whilst 'spotting' through the centre with a 4mm drill. Once this has been achieved, the 'spot' on the plate may be taken through with a 6mm drill in preparation for the plastic bushing.

Experience showed that it was best to cut the plastic bushing to just a little longer than the thickness of the plates (made from 6mm MDF board in this instance), and push them into place with a simple tool. This tool consisted of a piece of 4mm axle rod inserted into a handle with a sleeve of plastic bushing to provide a shoulder to push against the bush. A drop or two of cyanoacrylate adhesive applied just before the bush was pressed fully home, secured things firmly.

To locate the gears within the gearbox, short lengths of plastic bushing and washers acted as spacers. Pulleys were either glued onto the axle rods or locked into place with grub screws. The type of pulley used obviously determines the locking method used, but the use of grub screws proved to recommend this type of pulley above those that required the addition of adhesive.

Gearbox construction: evaluation

The success of this part of the project was testified by the fact that no pupil was confronted with a gearbox that didn't work smoothly at the end of his or her efforts! Whether compound gearing or worm gears were selected, good working pace was maintained, FPTs could be integrated well and bottle-necking on drilling machines could be easily circumnavigated.

The following tips are suggested to refine what appears to have been a successful aspect of the work:

- Fix both MDF plates together using small panel pins so that both may be drilled simultaneously. Check that the plates have been clearly identified to indicate which way round they should be after separation (use a couple of oblique lines drawn on one set of edges).

- To avoid the MDF plates 'riding up' on the drill during drilling, stops may be incorporated above the guide strips of the drilling jig.

- An empty 'squeezy bottle' or long handled brush proved to be a useful aid when clearing dust from the drilling jig between drilling operations.

- Use a hand-drill to drill clearance holes for the strip-fastening wood screws. This will relieve queues at the drilling machine and provide an alternative activity whilst others are drilling axle bush holes.

- One of the side strip securing screws also provided a useful fixing for a motor-clamp ('Terry' clip), in many instances.

- Avoid the temptation to paint gear-boxes. Paint is usually a guaranteed way of clogging bearing bushes!

- Plastic bush material may be cut longer than required and then filed or sanded flush with the surrounding surfaces once the cyanoacrylate adhesive has dried.

- A few drops of oil of liquid silicone works wonders at combating friction on both bearing surfaces and between gear teeth!

General Construction

Once the gear-box was constructed, work was started on the remaining parts of the ride. As mentioned elsewhere, pupils were encouraged to use items such as cotton reels as spacers, rollers or winding drums and cardboard postal tubes as support columns. The group were also made aware of the availability and working method for using MDF board, foamboard, 'Corriflute', cardboard and various strip materials. FPTs were covered showing the use of gusset plates to reinforce strip structures (so called 'Jinks-cubes'), and the method extended to illustrate how gusset plates can also reinforce forms made from MDF board or foamboard. The glue-gun was used to secure most MDF board structures completed in this way, with PVA adhesive used to hold foamboard. Due to a reasonably long setting time in the case of the latter, dressmaking pins were inserted to hold the components whilst the glue sets. Glass-headed pins were preferable to the standard steel pins both for their holding power and their later ease of extraction. To accelerate the setting-times of PVA used with foamboard, I have begun to investigate the use of a microwave with some success. Beware however if pins are used to secure the components as they will scorch the card! PVA used on wooden structures cannot be hardened quite so effectively by this method as the wood warms and keeps the glue soft for a considerable period of time. (PVA is a thermoplastic adhesive!)

Following the making of the gearboxes, some groups were encouraged to construct structures using dowel-rod to separate two side-plates in a similar manner to that used for this application. The resulting structure could then be clad on the four open sides using thin MDF board, foamboard, card or 'Corriflute', if required.

General construction: evaluation

No major problems were encountered at this stage of the work, apart from enticing the children away from a love of the glue-gun! It was seen by many as a taxing panacea and despite taxing FPTs recommending other methods, it was still perceived as the most immediate and time effective joining method.

The use of dowel-separated plates allowed good pace and resolved problems of paired components lining up incorrectly. Indeed, although many daily targets or six-week planners saw tasks taking less than realistic amounts of time, this was one construction method that actually ended sooner than anticipated.

Thick coloured card proved an invaluable resource for cladding purposes and was deemed entirely appropriate for this type of project. Furthermore it proved an inexpensive alternative to MDF board or 'Corriflute'.

Minor problems did occur in allocating tasks where partner working was allowed. Their resolution required some discussion with all parties concerned as tasks other than the main structure were seen as peripheral and lacking in interest by some partners.

Finishing techniques

The use of a teaching aid proved invaluable at this stage as it set a tangible standard to achieve. Undoubtedly, the girls within the classes put more effort into the finishing of the artefact, but it became important to avoid unnecessary embellishment taking over from good standards of finish.

Ready coloured materials (card and 'Corriflute') proved useful as many pupils were apprehensive about their ability to apply paint smoothly. Ironically, this situation was particularly the case with children of higher ability. Those of low ability were prepared to slap on coat after coat, apparently oblivious of runs and brushmarks! As many of the materials and components used had a good standard of surface finish, little sanding or refining was necessary.

The use of 'Corriflute', card and foamboard enabled the easy fitting of slide switches and access doors for battery-packs, using knives and a stitch ripper for the 'Corriflute'.

Assessment

Two forms of assessment instrument were developed.

- A Technology Scoring sheet.
- A topic-specific assessment sheet for the design and make aspects of the work.

The former of these two sheets proved invaluable for spontaneous formative assessment. Their ease of use also prompted me to adapt them for use in Key Stage 2 by non-specialist staff who were already beginning to highlight areas of National Curriculum documentation to suggest working levels for individuals.

The second of these assessment tools proved particularly pupil friendly and, although intended initially for summative and pupil self-assessment purposes, it was introduced fairly early in the project, enabling its use in a formative manner. Opportunities are given for self-assessment and end of topic target setting. Time needs to be set aside to discuss child responses on a class and individual basis, in order to reap maximum benefit from this form of documentation, but the degree of positive analysis that resulted made this activity extremely worthwhile. Experience has shown that target setting proved a complex task for even the most able pupils as strategies for improving performance tended to be very vague. I hope that by introducing this aspect of self-assessment to younger age groups, this element will be more highly refined by the time pupils reach Key Stage 3. In trialling evaluation tasks with younger age groups I have found that good responses appear to be a matter of experience and technique rather than overt cognitive ability. Indeed, many lower ability pupils appear far more circumspect or analytical than their higher ability peers. This observation was also found to be gender related as girls appeared to be prepared to be more self-critical than boys. This contributed, perhaps, towards their generally higher levels of achievement!

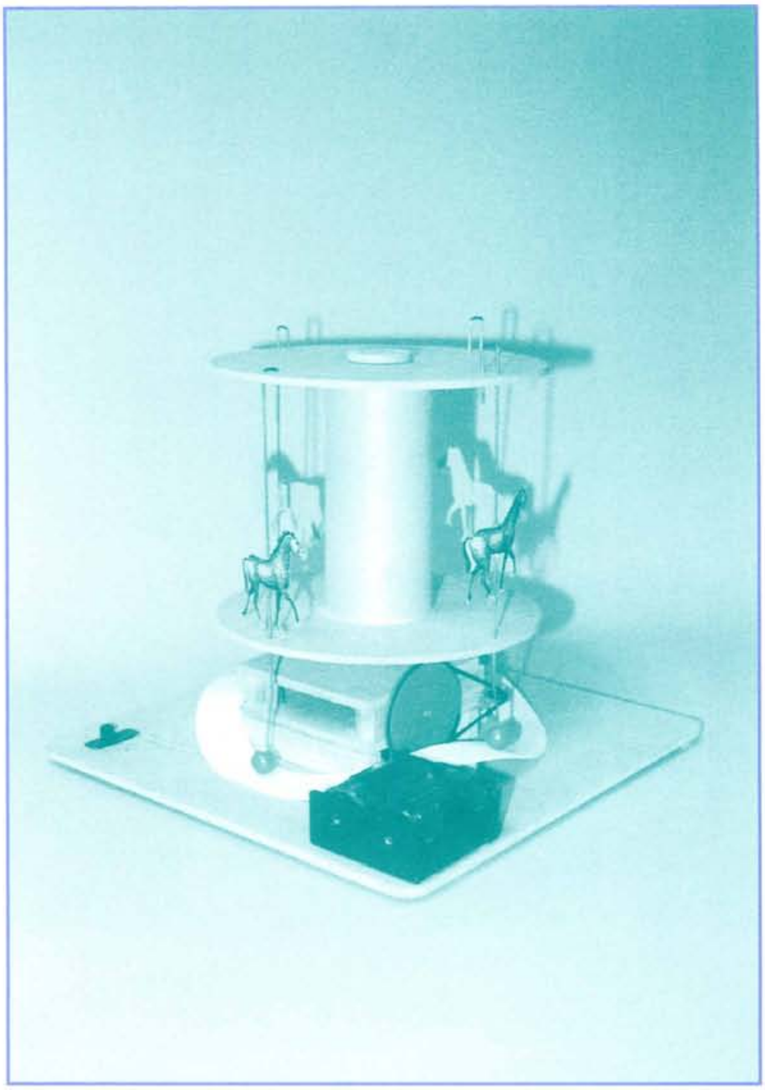
Conclusion

The degree of success encountered after moving this topic from Year 6 to Year 8 justifies the action taken. Enthusiasm levels were maintained throughout the project by the children who appreciated the importance of producing mock-ups with 'Lego-technic' and card. Once card or paper components were added to the Lego, it quickly took on the form of the intended proposal and removed itself from a simple construction kit. The kit became a component part of the design proposal and took on relevance.

Generally the children sketched their design solutions clearly and began to annotate well, but careful consideration needs to be given to the recording of ideas for mechanisms. At present, I am pursuing the idea of incorporating 'Lego-CAD' to draw mock-ups before sketching by hand.

The use of daily target sheets and six-week planners helped give structure to the planning activity, but a wide degree of differentiation is obviously required to cater for the numerous ability ranges that this task identifies.

What appeared initially to be the most daunting aspect of this design problem, resulted in being a relatively problem-free activity: Gear box construction using the methods shown, resulted in high precision modules with well suited gear ratios. They gave minimal frictional loss and had the potential to be built into virtually any conceivable fairground ride. A very desirable off-shoot of the gear-box proved to be the construction of open, box-type structures using the identical side-plate and dowel systems. This form of construction proved more adaptable, quicker to produce, stronger and more accurate than the ubiquitous 'Jinks-cube'.



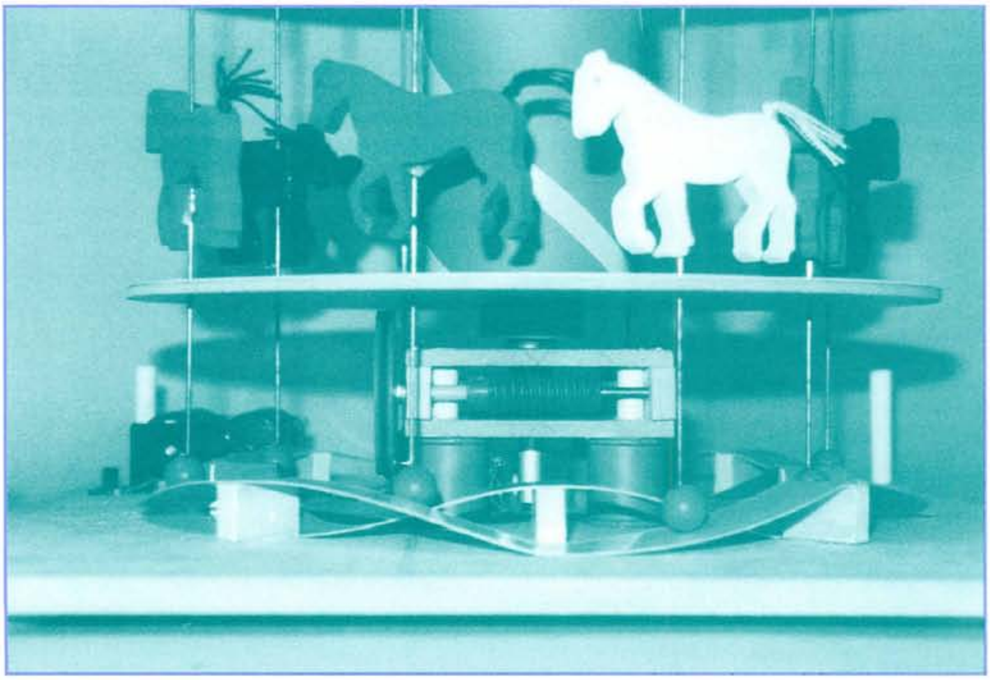
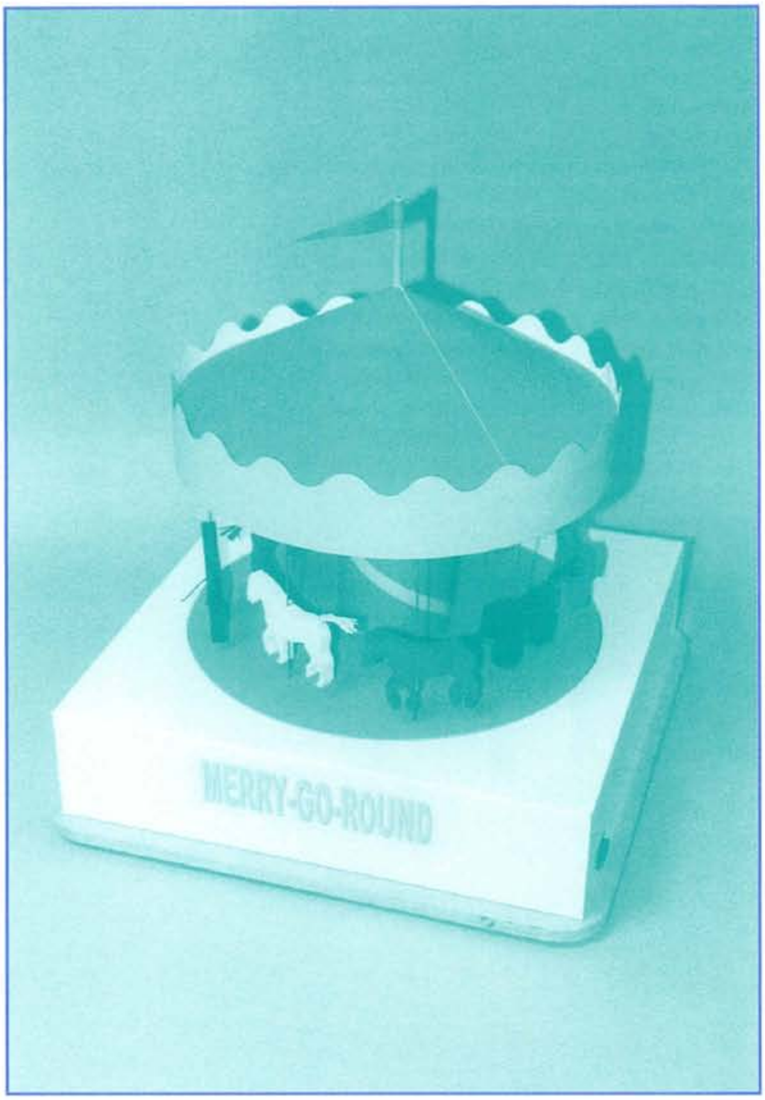


Figure 4: The basic Merry-go-Round



Finally, high standards of finish were usually in evidence as pupils had a reference point based upon the exemplar model. In artefacts such as this, it would otherwise be difficult to 'disassemble' this aspect of the product in the same way as proprietary items may be studied and evaluated.

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