Teacher roles during amusement park visits – insights from observations, interviews and questionnaires

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Abstract

Amusement parks offer rich possibilities for physics learning, through observations and experiments that illustrate important physical principles and often involve the whole body. Amusement parks are also among the most popular school excursions, but very often the learning possibilities are underused. In this work we have studied different teacher roles and discuss how universities, parks or event managers can encourage and support teachers and schools in their efforts to make amusement park visits true learning experiences for their students.

Keywords: amusement park physics, forces, PCK, informal learning, teacher CPD

Learning opportunities in an amusement park

Roller coasters and other amusement rides involve unusual motions in one, two and three dimensions. These motions often illustrate common textbook situations, such as free fall, circular motions, parabolas and pendulums, where the forces act on the human body of the rider [1-4].

A teacher can make use of amusement rides for physics teaching in many different ways. Even without amusement park visits, the rides can often be used as a "previous shared experience", supported by authentic data, photos and movies to illustrate different phenomena. How the teacher chooses to integrate the visit with the curriculum, including preparation and follow-up of the visit, is known to be play a large role for the learning outcome [5]. However, many factors influence if and how teachers choose to bring their classes outside the classroom [6], and it is known that other parts of the planning for the visit often overshadows the curriculum integration [7].

Amusement park visits can be arranged during regular opening hours, and possibilities for experiments and measurements may be negotiated, as well as access to power supplies and tables for equipment during the visit. The threshold for a visit can be lowered by making suitable data and possibly worksheets available on-line [8]. For first-timers, a quiz and joint class focus on 2-3 familiar rides can be a reasonable level of ambition, possibly combined with a preparatory lesson on force and motion in a playground [9]. With more experience, the teacher may choose to divide the class into groups of 3-6 students, focusing on 1-3 rides each and reporting back to the rest of the class after the visit. Electronic data collection is an option made easier with increased access to sensors in advanced mobile phones.

This paper focuses on teacher roles during organized science activities in an amusement park. We have been involved in Science days at Liseberg and Gröna Lund since 2002 and

2009, respectively. We continue to develop materials and format for the days, using observations, interviews and questionnaires to guide the development. We also build on research from other informal science learning environments, including studies of teacher roles in science centers [5,7], as well as models of effective professional development for teachers [10].

Force and motion in amusement rides

Our everyday motions are rarely limited to one dimension, and rarely uniform or uniformly accelerated, as in common examples used to introduce velocity and acceleration in school physics (and math). Amusement rides, on the other hand, offer many full-scale implementations both of these and other textbook examples, including the weightlessness in free fall, rotating coordinate systems and built-in parabolic "flights". However, in contrast to common textbook examples, where forces are rarely exerted on human bodies, the forces needed for the accelerated motions in amusement rides are experienced throughout the body of the rider. The vector character of velocity and acceleration are obvious to the person who is moving. Acceleration introduced through Newton's second law, $\mathbf{a}=\mathbf{F}/m$, is accessible also to young learners. By focusing on forces acting on the human body, also the traditionally difficult centripetal forces enter with the correct sign.

In many ways, the experiences of "holiday physics" in the idealized motions of amusement rides may be a more suitable concrete introduction to Newtonian mechanics than the special cases of rest of uniform rectilinear motion: Newton's first law seems to contradict the everyday experience, where a rolling ball comes to a stop on a horizontal surface and you need to keep pedalling your bike to keep it moving, even when there are no hills.

The ride experience of the body can be complemented with measurements and experiments using simple toys or mobile phones (after discussions with those responsible for rider safety). However, for minds trained to think of acceleration as a mathematical description from outside the moving system, the interpretation of the resulting accelerometer data from commoving sensors can be quite confusing. In spite of their name, accelerometers do not measure acceleration but the "g-force", $(\mathbf{a}-\mathbf{g})/g$, as a vector in a coordinate system that accelerates and rotates along with the rider. Trying the equipment in everyday motion and in ordinary playground swings [9] is a good preparation for measurements in amusement parks. The combination of many different representations of acceleration offers a number of qualitatively different ways of experiencing the phenomenon, and can be expected to lead to deeper understanding, that can be transferred to new situations [11,12].

The development of amusement park science days in Sweden

In 1995, rides in the Liseberg amusement park were used by university students in an introductory physics course, for investigations inspired by material from the US [8]. A first web site was created by students for us in later courses. This site has moved, and been updated and expanded into a large www site [13], used in many university courses as well as in schools. Student teachers at Stockholm university performed experiments and measurements at Gröna Lund and presented photos and results as inspiration [14]. For a number of years, school visits to have been arranged by individual schools. University and engineering students have done projects at Liseberg and we have converged on a format with 3-6 students, looking at 2-3 rides, with written reports, opposition and presentations following the visit. The discussions during the project work offer many opportunities for "elicit-confront-resolve" concerning force concepts. In 1999, a collaboration was initiated with zoophysiologists who measured heartbeat in a supervised pilot class visit at Liseberg. Supervised visits for pupils aged 10-16 became part of the school program in the Gothenburg international science festival 2000-2001. The experiments were developed in collaboration with park administration for safety and logistics, and with external financial support for graduate students to supervise class visit. In this close contact, experiments could be tried out, as well as questions and discussions before and after the rides. After these visits we felt ready for a larger science day. In 2002, 600 pupils had exclusive access for two hours to five rides, expanding to 2000 pupils with 14 rides for three hours in 2004. Students from physics, teaching and engineering education programmes at several west Swedish universities acted as observers and provided support at several rides [15]. Observation forms and reports from the participating students gave insight into the significant variations of teacher preparation and class interaction - and the difficulty to ensure that all classes came well prepared. Some of the material developed has later been adapted and integrated in activities at Tusenfryd [16] in Norway and Tivoli Gardens and Bakken in Copenhagen [17]

Science days at Liseberg resumed again in a smaller format in 2012, with enhanced teacher involvement, is discussed more below.

During recent years, the project has been taken up in the form of "Edutainment days" at Gröna Lund, in collaboration involving the House of Science in Stockholm and the Swedish National Resource Centre for Physics Education. Up to 3000 students and their teachers have had exclusive access to the park for three hours before opening. Questionnaires concerning preparation, visit and planned follow-up have been collected. However, getting responses directly from teachers is not always easy – in 2012 they were also actively solicited in informal interviews during the visit.

Table 1 summarizes the development since the year 2000, including types of data collected during the events. In this paper we present an analysis of evaluations, including interviews, observations and questionnaires, from these events, and also show how the results have been used for continued development.

Table 1. Data collection in connection with the development of physics, science and Edutainment days in Sweden

Period	Description	Data collection
2000-2001	Liseberg, supervised class visits, age 10-16, as part of the Gothenburg Science Festival. Continued development of web site and format in close interaction with a group of teachers.	Guide reflections. Focus group interviews with one group of 10-year olds.
2002-2004	Liseberg links physics material to liseberg.se. Science days, up to 2000 pupils + 200 students assisting	Student observation protocols + reports + informal discussions with teachers and summaries from park personnel.
2005-2012	University student groups at Liseberg. Independently planned class visits at Liseberg and Gröna Lund.	Student reports. Informal discussions and contacts with teachers.
2009	Separate teacher workshop at Gröna Lund.	Questionnaires and

Period	Description	Data collection
	1900 pupils at Gröna Lund. Detailed schedule: lecture on history, hands-on demonstration show from university + measurements in rides, with possibility to borrow accelerometers	observations
2010	Worksheets developed. Introductory activity at the House of Science	Discussions during a teacher follow-up meeting at the end of the Edutainment day
2011	Worksheets available at gronalund.com. Presented in some detail during workshop as teacher preparation for Edutainment day.	Questionnaires
2012	2900+1500 students at Gröna Lund. Technology table added Small-scale (600) physics day at Liseberg, with required teacher manning of ride stations.	Questionnaires, actively collected on-site. Dinner discussions after visit + e-mail follow-up
2013	Small-scale (600) physics day at Liseberg, with required teacher manning of ride stations. Individual e-mails to teachers.	Discussions + web questionnaire.

Teacher roles during class visits outside school

Teachers take on a number of different roles in connection with a visit, as known also from research at science centres [5]. Teachers may leave the class to roam around, possibly agreeing on meeting time, including a snack – described as a "soda pop visit" in [7]. Teachers may use the visit as an appetizer to start up an area of work - or as a resource or laboratory providing equipment not found in school. Lessons may be offered by the teacher or as a packet offered by the amusement parks [4], in which teachers may take part together with the students or choose to be absent [7]. We have seen all these roles taken on by teachers during different forms of amusement park visits. Amusement park visits also invite additional roles, e.g. as "bag guards", as an "equipment center" or "electronics support centre".

During the early science days at Liseberg, student teachers assisted at different rides, observed and discussed with teachers. Some of the responses during these early science days emphasized the need for additional support for curricular integration:

- The kids were only interested in the rides. The only discussions were about riding again or moving to another ride. The only preparation was travel information.
- "We prepared a little, but we will get most of the experience here. I suppose we should do some follow-up." He did not care about the experience of the kids.
- The teacher was a passive viewer, just making sure the groups followed the schedule. The kids were only interested in the rides. I could not observe any learning.
- The teachers we interviewed had no science background and couldn't answer the questions coming up.

The reports and discussions after the event showed that the student teachers were well aware of the importance of preparation and follow up. Meeting unprepared teachers and classes can be demoralizing, both for pupils and students. However, the students also met many well-prepared classes during the science days. Some classes came prepared with worksheets, sometimes based on questions formulated by the children before the visit.

- The children have made hypothesis to test. It is obvious that they use each other. Those who have experimented tell the others and those who haven't get more curious and have to try it for themselves.
- The children have written down hypotheses and are well prepared. The teacher poses questions and discussed with the children without giving answers. The intention is that the children think for themselves.

In some classes, the visit was part of a physics theme:

- The science teacher had told the class about the physics in various rides and what would happen. They had also experimented in swings.

Some classes had prepared their visits by doing research into various rides, working with potential and kinetic energy and building an amusement park in the classroom. Sometimes the teacher was observed to available for discussion at the end of the ride. In other cases, the teacher relied on the worksheets. Encountering many different teachers interacting in different ways with their classes gave the students an unique experience of a "teacher observatory", and of the importance of the teacher. One group reflected after the visit: "We knew that teachers play a role – but not that much".

Science day organization and teacher roles

During the first science day at Liseberg in May 2002, a relatively detailed schedule was suggested for the 600 pupils aged 10-19, as a way to obtain an even load on the five rides available and also to minimize interference between the different age groups. Reports from participating student teachers showed that this arrangement often prompted a teacher role focusing on keeping the schedule, and that many classes came unprepared for the physics activities and were more interested in the rides. During a couple of subsequent science days, classes were given a short introductory lecture in the park, but we found this format difficult to scale up. With an increased number of participants we chose instead to recommend different starting areas for different schools, and suggested worksheets with exercises related to a variety of rides. Seminars and workshops presenting the physics in the rides were offered as part of the Gothenburg international science festival.

Gröna Lund adapted the concept in 2009, in collaboration with the schools in Stockholm. During the first Edutainment day, the classes were divided into different groups, spending half the time on rides and the other half on presentations and experiment shows. Again, this prompted teacher preparations to focus on scheduling, and this format was abandoned, in favour of recommendations to assign different worksheets [13] to groups of 4-6 pupils and let them report back in class after the visit. This recommended format is based on many years of experiences or working with large groups of students following the development work in a new education programme in 1995 [18].

Teacher roles and Integration in the school curriculum

There are many thresholds to a visit [6]. Before the visit, many practicalities must be dealt with, including financial arrangements, scheduling, transport, information to students, colleagues and parents and collecting permissions needed. For the visit to contribute to student learning, the teacher must also become familiar with possible tasks in different rides and select and prepare assignments for the students, including equipment to be used.

From questionnaires and interviews during the days, we discern differences in the pattern of integration between classes in lower and upper secondary school (ages 13-16, and 16-19, respectively), as seen from Table 2.

One of many: Flow Analysis and Safety

Although planning is essential for a successful learning experience in an amusement park, not everything can be planned in detail. The time required for rides depend on choices of other visitors in the park, and the important safety regulations may get into the way of some creative experiments.

We found many frustrated upper-secondary students in queues, during an early Edutainment day, with the single assignment from their teacher to bring an accelerometer onto one of the two large drop towers at Gröna Lund while their teachers guarded their bags. When 3000 students share the park for three hours, not everyone can expect to go on a ride with a capacity of less than 400 riders/hour! At the same occasion, we met a large number of enthusiastic students, who had finished assignments for 3-4 rides, as we had recommended, and were moving onto a quiz and other shorter tasks.

During early stages of the development, participating students found pupils who tried to bring large mugs full of water along in high drop towers or to take a giant toy or beer can on a 1m string, rather than the recommended cuddly animal on a 30-40 cm string. We have seen attempts to bring graphing calculators with large sensors without any way to securing them to the body. Large elevations, high speeds and strong forces can cause as much damage on science days as every other time: Although some open-park safety rules may have be alleviated for the special days, Newton's laws still hold - they are usually what prompted the visit.

Table 2. Typical replies from lower and upper secondary school teachers concerning preparation and follow-up

	Age 13-16	**Age 16-19**
Preparation	• Go through force and motion concepts • Work through exercises from the www page • Groups have chosen topics	• Review equipment to be used • Go through what observations and measurements to perform in park
Follow-up	• Report + oral presentations in groups • Discussions in mixed groups • Individual responses to written	• Reports • Presentations • Hand in assignments

	questions + discussion in class • Discuss answers and solutions in groups • Orally with powerpoint • Discuss the ride experiences and try to understand the connection to the forces in different rides	

Supporting the teachers, before, during and after visits

How do we best support teachers to make use of the learning opportunities in an amusement park? Sagar et.al [6] have investigated what barriers and requirements teachers perceive for integrating collaborations outside school into the school curriculum, and identified a number of factors, including requirements on time, school leadership, scheduling and opportunities for professional development. During the early development of science days at Liseberg, we focused on the learning and involvement of students, and found that students who were uncertain about the physics involved were often reluctant to pupils' observations at the rides.

During the last few years, we have further developed the format for Edutainment days and Physics days at the Gröna Lund and Liseberg amusement parks in Stockholm and Göteborg, Sweden, building on experiences and materials from science days arranged at these and other parks. We have emphasized the recommendations to use worksheets and encouraged teachers to divide the class in groups of about 4 pupils who focus on 2-4 different rides. The groups then report back to the rest of the class, providing a richer experience. We have found that the use of worksheets with different rides helps circumventing long queues, where students cluster on a few popular rides. A technology table was added to the Edutainment day in 2012.

Information about rules, activities and recommendations do not automatically reach all participating teachers. It is common for one teacher to sign up several classes for a school, and be the one receiving all information. Unprepared classes not only miss out on learning opportunities, but also clog up popular rides, and change the general atmosphere of curiosity and excitement over new ways to experience familiar rides, including physics, math and technology. An important aspect of our development of the design of Edutainment days is the emphasis on the role of the teacher, supported not only through worksheets, but also by a workshop, where teachers have a chance to get familiar with the rides, as well as sharing and discussing previous experiences from working with the material, before during and after the visit. Schools participating for the first time in the Edutainment days are required to send at least one teacher to the workshop.

During recent Edutainment days at Gröna Lund tutors from the House of Science have been stationed at rides to help distribute and inspect any material going on the the ride. Since 2012 we also invited teachers to assist at some of the stations with tags showing their role. In this way teachers get to share experiences and discuss with pupils from different schools, as well as with tutors and graduate students. For the smaller Physics Days at Liseberg, e-mail addresses were collected for all physics teachers taking part, and they were assigned one hour at a ride station, together with a couple of colleagues from other schools, to discuss with all students going on that ride. Teacher instructions and dialogue suggestions (1-2 pages) for individual rides were made available before the visit and teachers did come prepared. Pre-visit e-mail contacts with all participating teachers seems to lead to increased involvement and sense of shared responsibility for the success of the day. The work continues, in international collaboration [19], to adjust the format to ensure that the days become optimal and enjoyable learning experiences, both for the classes, and their teachers.

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