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eMobility for Kids – a new learning workshop for 12-15 year olds

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Executive Summary

Electric mobility plays a key role in promoting climate-friendly transportation. However, many school students have had little opportunity to explore energy and electricity through hands-on learning. This inspired the creation of an innovative and practical teaching format using electric vehicles, closely integrated with the physics curriculum. First results are now available and are presented in this article. The project builds a meaningful bridge between classroom learning and real-world applications of sustainable mobility, aiming to spark curiosity and enthusiasm for linking the basics of physics with the exciting world of electromobility.

Keywords: Electric Vehicles, Light Electric Vehicles & Micro Mobility, Public Policy & Promotion, Education, Skills and labor market, Recycle and Re-use

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1 Introduction

The topic of energy was already introduced to children in the 1970s under the title Electricity, a children's book [1]. In addition to everyday devices such as electric stoves, televisions, and batteries, [1] notably also features an example of electric mobility, see Fig. 1.

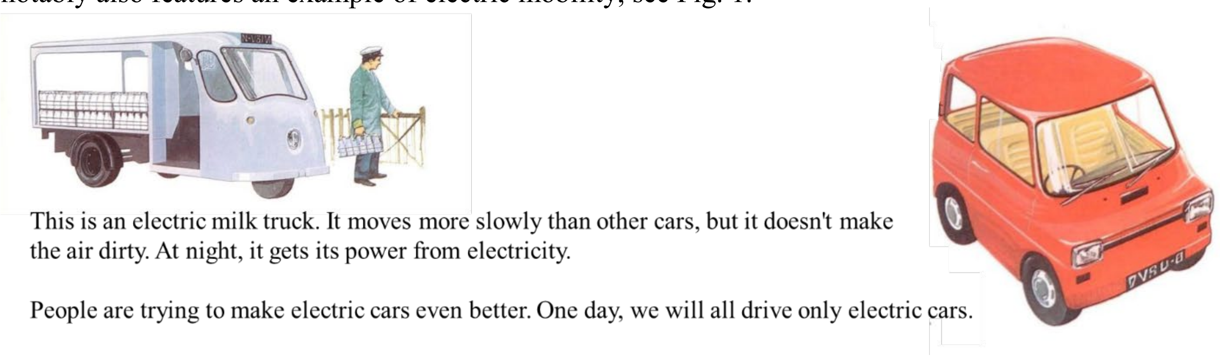

Figure 1: Electric Mobility as presented in a children’s book, based on [1]

As early as 1972, electric driving was presented to children as the mobility of the future! The book highlights key advantages such as lower emissions and the ability to charge overnight, while also pointing out the technological development still required.

For educators—whether in schools, at the school-to-university transition, or in the context of inspiring future generations to pursue technical degree programs—this raises an important question: how can we spark school students’ enthusiasm for a new kind of mobility?

1.1 Design Considerations for the Learning Format

Many years of experience within the author team in providing technical education for children and adolescents have shown that hands-on experimentation is a highly effective way to lower barriers and foster a personal connection to the world of technology. Motorized vehicles for children involve a certain degree of structural complexity, both in design and assembly. For this reason, the teaching and learning format eMobility for Kids (eM4K) was designed from the outset to target scholl students - a phase spanning late childhood and the transition into adolescence. Additionally, due to logistical considerations, the initial implementation phase was structured as a two-day "mini block week," scheduled during school holidays in the German state of Baden-Württemberg.

According to the principles outlined in [2], science education should build upon the existing conceptions and prior knowledge that learners bring with them into the classroom. One of the key objectives of the eMobility for Kids (eM4K) learning workshop is therefore to connect with school students' everyday and school-based understandings of mobility, and to explicitly develop them further. In doing so, school textbooks from the state of Baden-Württemberg are used as a reference point.

In line with the concept of interdisciplinary teaching [3], eM4K is designed as a hands-on project-based format that integrates subject-specific instructional sequences. Participants are encouraged to recognize the value of energy in the context of mobility, to collaboratively interpret and implement vehicle assembly instructions, and to engage—often for the first time—with both practical and theoretical aspects of vehicle kinematics.

Based on the authors' experience, further considerations indicate that a purely class-lecture-based format can sustain student engagement for no more than approximately two hours within a day-long program. Even with the integration of interactive sequences and multimedia elements such as videos, participants struggle to maintain attention over longer periods. The target age group in practice has settled at around 12 to 15 years of age.

Alternative formats in computer labs have been tested for the school-to-university transition, particularly through digital physics problem sets [4]. Experience shows, however, that inquiry-based teaching and learning methods tend to be more suitable for university students. One such application with practical sequences, implemented as a module in a master's program in Electromobility, is described in [5]. The modules in [5] focus on the use of simulation tools to model the longitudinal dynamics of electric vehicles, conducted either in on-site computer labs or through online instruction at home.

Within the eM4K learning workshop, establishing strong references to the structure and content of physics education as presented in school media is therefore seen as a key component.

1.2 Framework of the Learning Workshop

Following the preliminary considerations, the modular kits from the manufacturer Infento [6] were selected. Infento offers a range of vehicle kits suitable for STEM (Science Technology Engineering Mathematics) education from the age of 10 onwards. For the eM4K workshop, four kits of the so-called electric "Hot Rod Edu" were purchased, Fig. 2.

Figure 2: Manufacturer's electric vehicles [6] used in the eM4K learning workshop

As shown clearly in Figure 2, components such as the frame, the steering column, and the front axle can be assembled in parallel by different team members. The battery, which is mounted on the steering column, and the electric motor, which is attached to the frame, are installed at the end of the assembly sequence. One fully assembled vehicle serves as a reference model during the construction process. Three additional vehicles are available as kits, with all parts pre-sorted into component kit boxes, see Fig. 3.

Figure 3: Kit Boxes and Instruction Manual for Vehicle Assembly

The component kit boxes contain clearly identifiable individual parts, organized in a way that is easy for school students to recognize. Also included are assembly instruction manuals designed to support the modular, kit-based construction of the vehicles. The vehicles are assembled over two days by three teams, each consisting of four school students. Each team is supported by three university students acting as mentors, while two additional university staff members assist with organizational matters.

These staff members also deliver accompanying lecture segments in the school student lab and pay particular attention to the development of school students' competencies in communication and collaboration as integral aspects of problem-solving.

The learning workshop takes place in the university's large cafeteria, which is partially available during selected holiday weeks. Test drives are conducted outdoors on the university campus in good weather and indoors in case of rain.

2 Operational Phase of the Learning Workshop

In 2023 and 2024, the eM4K learning workshops were conducted three times per year, and three sessions are planned for 2025. The current structure of the format (see Tables 1 and 2) begins on day 1 with the setup of the component kit boxes and the reference vehicle at the workshop venue.

Table 1: Schedule of the eM4K Learning Workshop, day 1

No	Time schedule	Tasks
1	8:30 Preliminary meeting day 1	Preparing component boxes and reference vehicle
2	9:30 Workshop kick-off – day 1	Large cafeteria, transition to Education Studio, lecture "Electric Car History"
3	10:00 Start assembly day 1	Collaborative Vehicle Assembly
4	12:30 Lunch break – day 1	Large cafeteria
5	13:15 Lecture day 1	Education Studio, experiment and lecture "Vehicle Kinematics"
6	14:00 Continued vehicle assembly	Start of Assembly of Subsystems
7	15:30 Close of day 1	The partially assembled vehicles remain in large cafeteria

Table 2: Schedule of the eM4K Learning Workshop, day 2

No	Time schedule	Tasks
8	8:30 Preliminary meeting day 2	Large cafeteria, school student arrival
9	9:30 Workshop kick-off – day 2	Education Studio with lecture and experiment “Power, Energy and Charging”
10	10:15 Continued assembly of vehicles	Large cafeteria, final assembly of subsystems and tests
11	12:30 Lunch break – day 2	Large cafeteria,
12	13:15 Final assembly, first test drives	Large cafeteria, outdoor or indoor
13	14:00 Driving course challenge	Vehicle Handling Skills with parking and reverse driving
14	15:30 End of the workshop	Satisfaction Survey and school student pick-up

An impression of the supervised vehicle assembly is provided in Fig. 4. Another essential component of the eM4K format is the so-called Education Studio. This dedicated event space hosts the introductory lecture on the “Electric Car History” (No. 2), the instructional unit on simplified “Vehicle Kinematics” (No. 5), and the lecture on “Power, Energy, and Charging” (No. 9).

Figure 4: Scenes from the vehicle assembly supported by student mentors

According to Fig. 4, a university mentor student coaches a team of four participants. On day 2, the vehicles are fully assembled from the individual components and equipped with the drive unit and battery. Setting up the driving course is also part of the teams’ responsibilities - this may include a precision course for parking maneuvers or a longer test route outdoors (see Fig. 5).

Figure 5: Practical driving course for the eM4K workshop

It becomes evident that the school students show an exceptional level of enthusiasm during vehicle assembly—so much so that transitioning them to the Education Studio is typically only possible at the start of the day or after the lunch break.

The concept of a circular economy can also be applied—at least in part—to the vehicles. Within the eM4K learning workshop, participants learn that waste production during the assembly process is minimal. Due to the design and the materials used, all vehicles can be fully disassembled. Remarkably, school students also approach this disassembly phase—along with sorting the parts back into the component boxes—with enthusiasm, thereby experiencing circularity firsthand.

This disassembly phase also serves as a time buffer in case of delays during assembly or for organizing the transfer of school students from the university site.

3 Linking the Learning Workshop to the School Curriculum

As a basis for referencing the content of the learning workshop, the 2022 updated curriculum of the state of Baden-Württemberg for secondary schools (Gymnasien) is used [7]. This curriculum is also implemented in the state-approved school textbooks [8], [9].

3.1 Vehicle Kinematics in Circular Paths

In the textbook *Universum Physik 7/8*, designed for grades 7 and 8, one of the competencies aligned with [7] is the ability to "describe and classify motion verbally and using diagrams (in terms of time, position, direction, path shape, and speed)" [7]. Circular motion is only mentioned briefly in this context.

In grades 9 and 10, this is expanded to include the competency, as defined in [7], of being able to "describe uniform circular motion using radius and tangential velocity." In [9], this is supported by a dedicated chapter on circular motion, which introduces terms such as arc radius and angular velocity.

Within the workshop schedule, workshop item No. 5 addresses basic geometric relationships relevant to vehicle dynamics. As part of the learning workshop, an additional lab experiment is conducted in the Education Studio. Each participant constructs a so-called pivot steering mechanism using kit components—a steering concept commonly experienced by children in everyday life through devices such as handcarts, see Fig. 6 left.

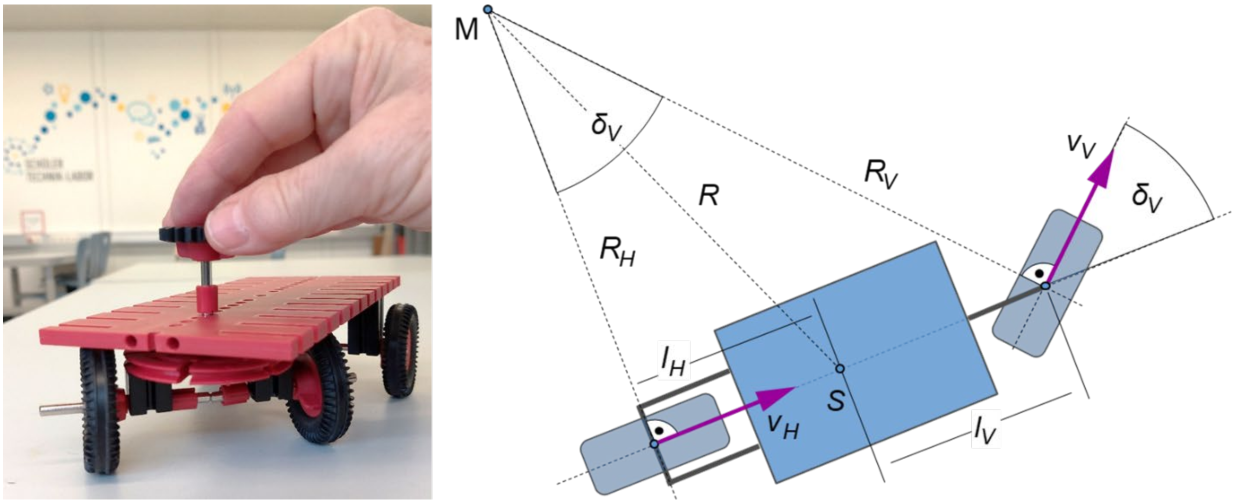

Figure 6: Handcart construction kit (left) and single-track model of vehicle dynamics [10] (right)

With this handcart, participants can set circular arcs and independently conduct basic driving experiments on the school student lab tables.

A first theoretical investigation of the four-wheeled Infento workshop vehicle is the so-called single-track model of vehicle dynamics [10]. This model makes it possible to apply the simple steering principle of the handcart to four-wheeled vehicles at low speeds (Fig. 6 right).

The single-track model is a simplified, planar model in which the wheels of the steered front axle (index V, steering angle δ_V) and those of the rear axle (index H) are each represented by a single wheel. From the center of the circular path M, different arc radii R_R, R and R_V emerge. The school students are reminded that the velocity vectors v_V and v_H are tangent to the circular path ("velocity arrow" [9]).

Based on the vehicle reference point S and the distances to the front and rear axles l_V and l_H, a relationship can be derived between the steering angle, the arc radii, and the vehicle geometry.

Initial experiences with this learning unit indicate that school students around the age of 15 are able to understand this relationship, including its trigonometric formulation. Future sessions will show how large this group of students might be. The relationship between steering angle, vehicle geometry, and circular path radius can even be explored directly on the self-built Infento vehicle using a simple tape measure.

3.2 Power and Energy

In the textbook *Universum Physik 7/8* [8], designed for grades 7 and 8, students are expected to "describe energy transfer in electric circuits and the relationship between current, voltage, power, and energy," as well as to "interpret physical specifications on everyday devices (voltage, current, power)". Additionally, they should be able to "describe the formulaic relationship between energy and power, $P = \Delta E/\Delta t$" and "determine the orders of magnitude of typical power values in everyday life" [7]. The textbook [8] includes an experiment on the power and energy consumption of devices as shown in Fig. 7.

Figure 7: Experiment on measuring power and energy consumption of an electrical device from the physics textbook [8]

In the eM4K learning workshop, students are provided with an energy meter, a suitable power outlet, and an electrical appliance (e.g., an electric kettle) to conduct a simple experiment in the Education Studio. During the workshop's timeline, this activity is represented by item No. 9. In the Education Studio, participants are also tasked with determining the energy consumed during the charging process of the Infento vehicle's battery by analyzing a graph of the measured power over time as shown in Fig. 8.

This determination can be performed graphically by dividing the area under the power-time curve into rectangles and summing their areas. This exercise leads to the understanding that there is always some energy loss when charging a battery, which depends on the quality of the components and must be accounted for as efficiency in the overall energy balance.

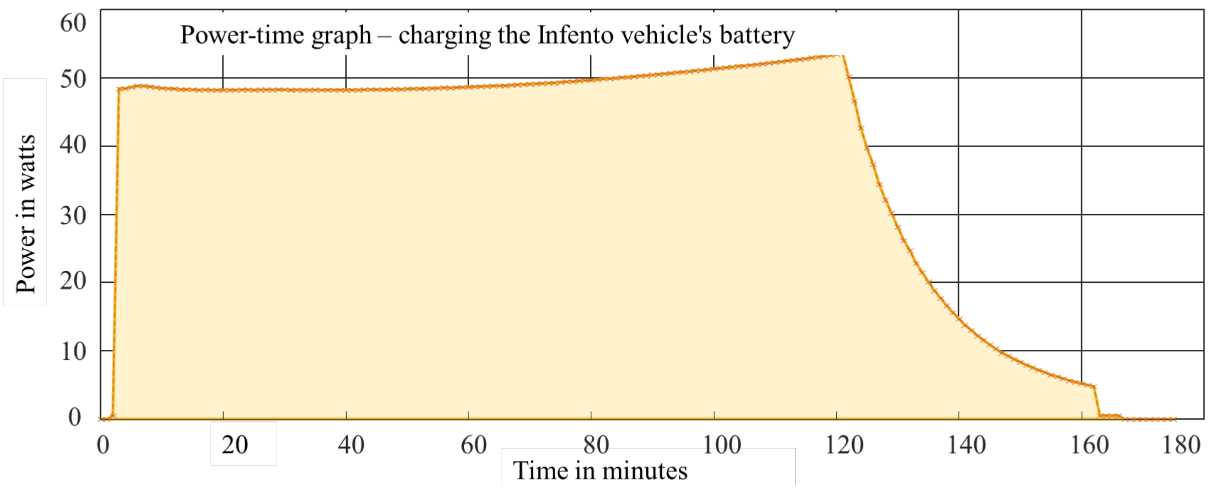

Figure 8: Worksheet for calculating energy from a power-time graph

In the eM4K learning workshop, the commonly used term "charging time" in today's mobility context is illustrated. However, the typical terms "range" and "charging time" for electric vehicles are not mentioned in the current curriculum of the state of Baden-Württemberg [7].

4 Summary and Future Perspectives

The eM4K learning workshop format was successfully implemented in 2023 and 2024. Nearly all participating school students showed great enthusiasm—whether during vehicle assembly, the instructional units in the Education Studio, hands-on testing, or even the disassembly of the vehicles.

From the perspective of the supervising university team, the experiences can be summarized as follows:

- The number of teams, each consisting of four participants per vehicle, will not be increased further due to the rising demand for supervision. Currently, three workshop vehicles are in use.
- Adequate space must be allocated for driving the vehicles—indoors as well in case of bad weather. Additional storage space is also required for keeping the component boxes between workshop sessions.
- The workshop has also proven valuable for the student mentors, as it fosters key competencies in communication and instructional support.
- The participant age group should not be lowered to avoid overburdening younger school students. All participants demonstrated competent handling of tools, aluminum profiles, and standardized components. Moreover, the selected age group is seen as critical in potentially influencing future study decisions toward STEM fields.
- School students found it particularly engaging to experience the production, use, and recycling of a vehicle in a two-day "time-lapse"—a process that in the real-world automotive industry takes years across all three phases.

The further development of the learning workshop will be guided by the experiences gained in the 2025 sessions.

Acknowledgments

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References

[1] N.N. *Meine erste Bücherei – 38 Elektrizität*, Frankfurt am Main, Brönner Kinderbuchverlag, 1972.

[2] T. Wilhelm et.al., Unterrichtskonzeptionen für den Physikunterricht, ISBN 978-3-662-63052-5, Berlin, Springer Verlag, 2021.

[3] L. Snead and Y. Simms, *Exploring Physics and Technology*. Improving K-12 STEM Education Outcomes trough Technological Integration, ISSN 2329-5929, Hershey, IGI Global, 2016, 312-336.

[4] A. Daberkow et.al., *Freie digitale Lern- und Lehrmaterialien für die Grundlagenphysik – ein Werkstattbericht*. MNU-Journal 2024(1), ISSN 0025-5866, Neuss, Klaus Seeberger Verlag, 8-13.

[5] A. Daberkow. *Ein exploratives Lehrformat zur Elektromobilität im Kontext des forschungsorientierten Lernens*. Zeitschrift für Hochschulentwicklung, ISSN 2219-6994, Lustenau, Verein Forum neue Medien in der Lehre Austria, 2020, 209-222.

[6] *Infento Hot Rod Edu*, https://www.infento.com/product/pro-kit/ , accessed on 2024-10-28

[7] *Bildungsplan Baden-Württemberg des Gymnasiums Physik - überarbeitete Fassung vom 25. März 2022*, https://www.bildungsplaene-bw.de/,Lde/LS/BP2016BW/ALLG/GYM/PH.V2 , accessed on 2025-04-22.

[8] R. Brand et.al., *Universum Physik Baden-Württemberg 9/10*, ISBN 978-3-06-012074-1, Berlin, Cornelsen Verlag, 2016.

[9] B. Bogenberger et.al., *Universum Physik Baden-Württemberg 9/10*, ISBN 978-3-06-012076-5, Berlin, Cornelsen Verlag, 2018.

[10] R.N. Jazar. *Advanced Vehicle Dynamics*, ISBN 978-3-030-13060-2, Berlin, Springer International Publishing, 2019.

Presenter Biography

Prof. Dr.-Ing. Andreas Daberkow received his PhD at Stuttgart University in 1992. He started his automotive career at the Frankfurt Research Center of Daimler Benz. Since 2009, Prof. Daberkow lectures in the ASE degree program of Heilbronn University (HHN). He was responsible for Digital Learning and is doing research on light electric vehicles in urban-regional operation. He has a Research Professorship for electromobility.