Can wearable technology be used to increase learning and wellbeing?

LEARNING STORY – FINLAND

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Summary

The Learning story evaluates a Finnish school's experiment using sensor-based learning in multidisciplinary teaching, aiming to enhance students' wellbeing and learning. Students (ages 13-17) used different wearable sensors, collected data from with them and analysed self-produced wellbeing data in aim to learning the phenomenon and increasing the personal wellbeing. Findings suggest that learning becomes more engaging when personal data is involved, with the majority of students finding it beneficial for their wellbeing.

Quick reference sheet	
Country	Finland
For whom is the learning story?	Teachers, educators in technology, health and wellbeing professionals in education
What is it about?	Integrating sensor-based learning technology for multidisciplinary education
Target group in the learning story	Lower and Upper Secondary Education (students aged 13-17)
The focus of the learning story	Practical use of digital wellbeing data for enhancing learning and wellbeing
Keywords	Sensor-based learning, digital wellbeing, multidisciplinary teaching, data utilisation in education, wearable technology

Background

Sleep, physical activity, and recovery from stress are crucial for wellbeing and learning. Concerns have been raised about the wellbeing of Finnish school-aged adolescents, who are reportedly engaging in less physical activity and sleep than in the past. Furthermore, school exhaustion and stress has increased among young Finns. The Ministry of Education reports that three-quarters of Finnish upper secondary students suffer from negative emotions like fatigue, stress, anxiety, and boredom, with only one quarter feeling positive emotions such as enthusiasm toward school. Additionally, a growing negative attitude toward school and a lack of motivation have been noted among Finnish pupils.

The aim of this learning story is to develop new teaching methods that could increase students' motivation and to provide them with new and beneficial information about their wellbeing. This is important, because wellbeing is the basis of learning.

At the University of Jyväskylä Teacher Training School, since the 2010s, there has been active experimentation and research related to sensor-based learning, learning data mining, and the development of learning environments. For example, one theme of Moilanen's (2020) doctoral thesis was to explore how wearable technology could be utilised in learning about different phenomena. In recent years, interest in using sensor-based learning technologies in science education has grown. The idea of using wearable sensors has been used for a long time in sports training to give feedback to an athlete, but in the field of education there are few studies that explore how new technology could be used as a beneficial educational tool to enhance learning through an authentic learning experience. Self-generated data can be more interesting and more practical for a student than the traditional examples of teaching methods. When the phenomenon is studied with the data produced by students' bodies it can increase motivation and enhance learning. At the same time, the students learn about their own health behaviour.

Wearable technology has evolved enormously over the last few years; it has become more precise, cheaper and its usability has developed. Sensors can now be used to collect versatile data about students´ wellbeing, health and exercise. Smartwatches can nowadays measure wellbeing data from the wrist (heart rate, heart rate variability, stress, amount of sleep, number of footsteps, calories, exercise load, VO_2-max-estimation) and they include for example accelerometers for movement analysis, location tracking, temperature and air pressure sensors. The data can be analysed from the perspective of different disciplines in the school. To collect wellbeing data and measure pupils' stress levels and recovery, we used for example Polar M-smartwatches and Firstbeat Bodyguard2, a heart rate sensor targeted for long-term monitoring of heart rate variability (HRV). HRV is a non-invasive marker of autonomic nervous system (ANS) activity, and HRV-based methods can be used to measure pupils' stress and recovery.

The data can be used for different purposes in sensor-based learning. For example, if the studied phenomenon is stress, students can then analyse their self-measured stress data to study in which situations they feel stressful and which factors increase their daily stress levels. This can promote motivation for studying the phenomenon and the obtained data can help them to improve their quality of life and personal wellbeing. In addition, the same data could be utilised by doctors and school nurses in preventive health care. In the longer-term, accumulating big data provide opportunities for data scientists to generate new interesting data-driven hypothesis and develop innovative tools and services for teaching. The following picture illustrates the possibilities of using data at school in sensor-based learning.

The aim of this learning story is to explore how students perceived new methods from the point of view of their learning and assess whether the teaching methods provided new information that could promote their own wellbeing. We also studied how to collect digital wellbeing data from a relatively large number of students (N=198) and how the collected big data set can be used.

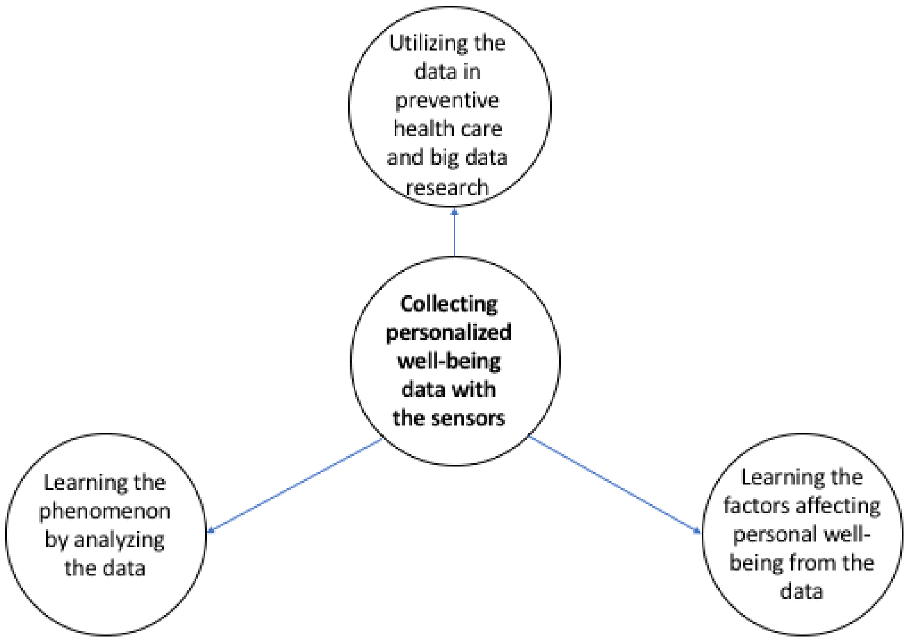

Figure 1 Pedagogical model of the project

The implementation[1]

Case 1: Lower Secondary School

The study was conducted in a lower secondary school in Central Finland, involving approximately 300 pupils. The school's theme for spring 2017 focused on "Taking care of oneself and everyday life skills." In preparation, 60 teachers were divided into three interdisciplinary teams (X, Y, Z) in August 2016. Each team, representing various subject areas, designed a three-hour learning package. These workshops were held three times during the spring, with about 100 pupils participating in each session. Care was taken to ensure each group included students from all grades.

Team Y developed a workshop centred on sleep, stress management, and physical activity. Pupils were offered the opportunity to participate in the Firstbeat Wellbeing analysis, which provided personalised insights into their stress levels, recovery, sleep quality, and physical activity. The Firstbeat Bodyguard 2 sensors, borrowed from Firstbeat and the University of Jyväskylä, were prepared and distributed by the class teacher two weeks before the theme day. Students were instructed to wear the sensors from Thursday morning to Sunday morning to capture data from

[1] This learning story was explored with interview videos in the Agile EDU MOOC, which can be viewed under Section 2.3 of the course.

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both school days and the weekend, allowing comparisons between the two. Throughout the process, the researcher-teacher actively reminded students and parents to ensure maximum participation. The sensors were collected a week before the theme day, allowing enough time to upload the data and prepare individual feedback.

On the theme day, students were divided into three groups. Each group received personalised feedback based on their wellbeing data, highlighting areas such as stressors, recovery sufficiency, sleep quality, and physical activity. A total of 182 students participated in the analysis, while those who did not completed a multiple-choice questionnaire on their general wellbeing. Afterwards, all groups rotated through three 45-minute workshops focused on sleep, physical activity, and stress management.

The **stress management workshop** included relaxation exercises such as breathing techniques, calming music, visual aids, and short massage sessions. Pupils also reflected in small groups on their personal stress management strategies and shared tips with peers. In the **sleep workshop**, students learned about the significance of sleep, explored solutions for sleep-related issues, and concluded the session with a Kahoot quiz. The **physical activity workshop** combined technology and movement, engaging students in activities like Just Dance, Sprint, and the SportsTracker application.

This multidisciplinary approach provided pupils with valuable insights into their wellbeing and equipped them with practical tools to improve their everyday habits.

Case 2: Upper Secondary School

The upper secondary school phase of the study introduced an optional multidisciplinary course titled "Exercise, Wellbeing, and Measuring", aligned with the Finnish national curriculum. It integrated various subjects to explore themes such as physical activity, stress and time management, sleep, and nutrition, aiming to use sensor technology for students to measure various physical parameters and improve wellbeing through analysis feedback.

Students used Polar M200 smartwatches and underwent Firstbeat's wellbeing analysis twice, alongside using sleep monitors and mobile applications like Sports Tracker and Polar Flow which are free and usable by anyone with a smartphone. The Firstbeat Wellbeing Analysis is a tool that uses data from wearable sensors to assess an individual's stress levels, recovery, sleep quality, and physical activity. It relies on heart rate variability (HRV) measurements to provide personalised insights into how the body responds to daily activities, helping users understand their wellbeing and make informed lifestyle changes to improve their health and performance. Additional health measurements, including arterial stiffness, VO_2 max, body composition, and Finnish national physical functional capacity tests, were conducted. A lab was established for further measurements like blood glucose and lung volume, and experts visited to supplement the learning. **VO_2 max** (maximum oxygen uptake) is a measurement of the maximum amount of oxygen an individual can utilise during intense exercise. In the course, VO_2 max was measured using Polar M200 smartwatches, which estimate VO_2 max based on heart rate data, physical activity levels, and algorithms designed for this purpose.

Students' tasks included analyzing recovery, sleep monitoring, physical activity, and blood pressure through data collection and interpretation, as well as a vertical jump test to study the relation between physical performance and recovery, a technique used by Finnish ski teams. The study aimed to empower students with self-knowledge about their wellbeing, hoping to inspire healthier lifestyle choices. **Recovery** refers to the body's process of restoring balance and returning to a state of readiness after physical, mental, or emotional stress. It involves the ability of the body to repair itself, replenish energy stores, and return to a relaxed state after periods of exertion or stress.

Polar M200 smartwatches were used throughout the several-weeks of the course. They provided continuous tracking of physical activity, sleep, and calorie consumption, offering a comprehensive dataset for analysis. Students were prepared for the data collection at the beginning of the course, where they received detailed instructions on using the devices. Each student created a personal account for the **Polar Flow** app, paired the smartwatches with their smartphones, and learned how to sync their data to the cloud.

The data was automatically recorded and stored in the **Polar Flow cloud**, making it accessible to both students and teachers for analysis. Additionally, students participated in **Firstbeat Wellbeing Analysis** twice during the course—once during a regular school week and again during the exam period. This analysis involved wearing **Firstbeat Bodyguard2 sensors** for a few days, with the collected data manually uploaded by the teacher-researcher to the Firstbeat server for personalised feedback. This dual approach ensured that students were well-informed and engaged with their personal wellbeing data, linking it to course concepts in a meaningful way.

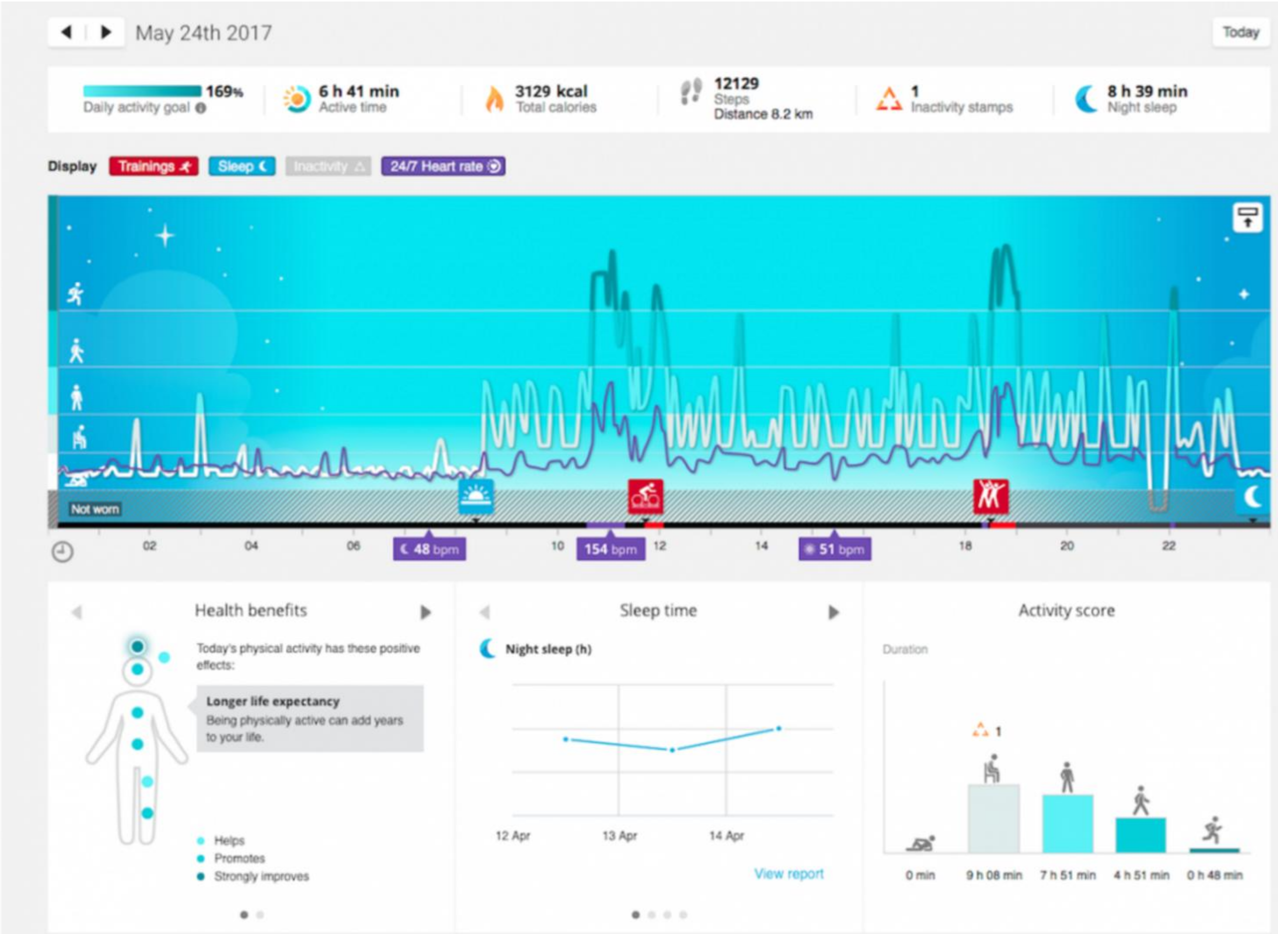

Figure 2 A screenshot of the Polar Flow data visualization of a student

The screenshot (Figure 2) from the Polar Flow server shows a student's detailed activity and health metrics, including daily activity percentage, active time, calories burned, steps taken, distance covered, inactivity stamps, and night sleep duration. It also features a 24/7 heart rate graph highlighting activity intensity, sleep phases, and recovery periods. Additional insights include health benefits of physical activity, sleep time trends, and activity distribution. Students can benefit from this data by understanding their physical activity patterns, identifying periods of inactivity, and linking sleep quality to their overall wellbeing. This personalised feedback helps them make informed decisions to improve fitness, recovery, and daily routines.

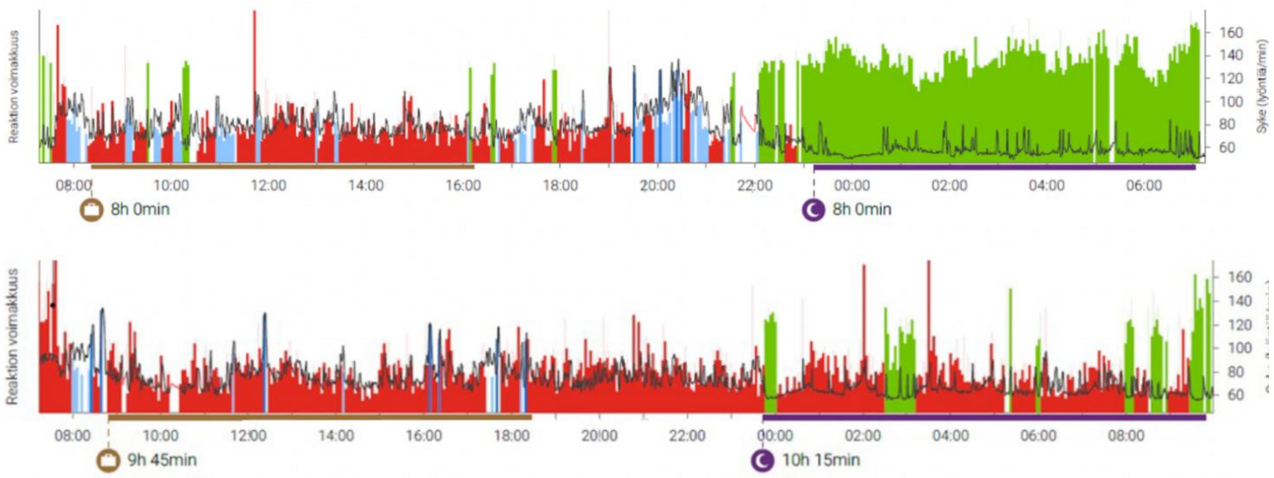

Figure 3 Student's Firstbeat analysis screenshot

The Firstbeat Wellbeing Analysis screenshot (Figure 3) shows two days of heart rate variability (HRV) data, visualised in different colours to represent physiological states. **Red** indicates stress or active work (sympathetic nervous system dominance), **blue** represents **increased physical activity**, such as walking or moderate exercise. It signifies a state of heightened energy expenditure and **green** shows recovery during sleep. The black line shows heart rate (in beats per minute), and the timeline marks the progression of the day and night.

The "good day" features more green (better recovery during sleep) and occasional blue segments during the day, indicating moments of relaxation. The "bad day" has prolonged red periods, minimal recovery, and disrupted or shorter sleep.

Students can benefit from this data by identifying how their daily habits, activity levels, and sleep routines affect their stress and recovery. They can use these insights to make adjustments, such as incorporating relaxation techniques, managing stress, and prioritizing better sleep habits to enhance their overall wellbeing and learning capacity.

The students responded to an electronic questionnaire at the end of the wellbeing courses. In general, students evaluated their experiences of sensor-based learning in both cases positively. All upper secondary school and 87% of lower secondary school pupils argued that when they work with data produced by their own bodies, then learning is more interesting. Most of them also found that wellbeing analysis was useful (upper secondary 97%, lower secondary 78%) and can improve personal wellbeing (upper secondary 78%, lower secondary 67%). When the students were asked, which things / tasks / assignments were the most useful or most effective for their learning, 84% of the students´ answers included some of the measurements related to own body. Lectures held by experts were mentioned in 32% of the students´ answers. Some students also argued (8%) that writing the project work of the course was effective for their learning and 5% of the students´ perceived discussion in groups as useful. The students were also asked which part of the course was best remembered and 72% of the students´ felt that the measurements were best remembered after the course. Lecturers were mentioned in 36% of the students´ responses.

Lessons Learned

Key recommendations emerge from the learning story:

1. Collaborative Planning

- Form multidisciplinary teams of teachers to design workshops or courses that integrate wellbeing data collection with subject-specific learning goals.
- Encourage collaboration across subjects like physical education, biology, mathematics, and ICT to create comprehensive, engaging learning experiences.

2. Student Participation

- Provide students and parents with clear instructions and materials, including wearable devices, user guides, and consent forms.
- Use digital communication platforms (e.g., Wilma) to send reminders and updates throughout the project to ensure smooth participation and device returns.

3. Technology and Tools

- Select appropriate wearable devices, such as HRV sensors or smartwatches, that are easy to use and provide relevant wellbeing data (e.g., stress, recovery, sleep, activity levels).
- Ensure devices are preconfigured with detailed instructions for setup, usage, and data synchronisation to minimise technical challenges.

4. Data Collection

- Plan for measurements over multiple days (e.g., weekdays vs. weekends) to capture a comprehensive view of student wellbeing and recovery patterns.
- Distribute and collect sensors efficiently, ensuring they are ready to use and returned promptly to manage large groups effectively.

5. Workshops and Feedback

- Incorporate functional workshops focusing on stress management (e.g., breathing exercises), sleep education, and physical activity (e.g., interactive games).
- Provide personalised feedback reports to students, helping them understand their wellbeing metrics and identify areas for improvement.

6. Integration with Curriculum

- Align sensor-based learning activities with curriculum objectives. For instance:
  - Analyse stress or sleep data in biology lessons.
  - Use activity and recovery data for graphing or analysis exercises in mathematics.

- Design hands-on tasks where students apply their data in real-world contexts, fostering deeper learning.

7. Student Engagement

- Use gamified tools like Kahoot quizzes or interactive apps (e.g., SportsTracker, Just Dance) to make learning fun and engaging.
- Facilitate group discussions to help students reflect on their wellbeing and learn from peers' experiences and practices.

8. Ethics and Sensitivity

- Obtain parental consent for minors and ensure compliance with data privacy regulations.
- Avoid sensitive measurements, such as body composition, that could cause discomfort or negatively impact students' confidence.
- Follow data protection laws (e.g., GDPR) to ensure student data is securely stored, processed, and anonymised where possible.
- Use secure platforms for data storage and analysis, limiting access to authorised personnel only.
- Avoid collecting unnecessary or sensitive data to minimise risks.

9. Teacher Preparation

- Provide training for teachers to familiarise them with the technology, data collection process, and tools for analysing wellbeing data.
- Offer resources, including ready-made lesson plans and teaching aids, to support the integration of sensor-based learning into their teaching.

10. Evaluation and Feedback

- Use student surveys to evaluate the effectiveness of the activities, identifying areas for improvement and gauging interest levels.
- Collect feedback from both students and teachers to refine future implementations and ensure activities remain meaningful and engaging.

By following these recommendations, teachers can effectively implement sensor-based learning initiatives that enrich students' understanding of wellbeing, promote interdisciplinary learning, and foster meaningful connections between personal health and academic content.

Current and future projects

Our current projects and research pilots are developing and studying methods to integrate data from wearable sensor technology, which measures the learner's physiology, with survey data that measures subjective experience. This integration can provide new insights into factors related to the learning process and environment. For such research, in 2023, the Teacher Training School built a research classroom utilizing XR technology, which can create, for instance, a Finnish forest, the ancient Colosseum, or any other supportive learning landscape through XR technology. Exploring innovative ways to engage students, a Finnish school implemented sensor-based learning, utilizing self-generated wellbeing data in a multidisciplinary approach. This aligns with the Finnish national curriculum, emphasizing ICT and collaborative learning. The study seeks to understand this method's impact on learning and personal wellbeing enhancement.

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