

Digital tools in teaching physics at university level – challenges and lessons learned

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Pro > Software & Services

ChatGPT threatens education at all levels - here's how it can be stopped

Features By Lewis Maddison published February 11, 2023

If students can cheat using ChatGPT, then what can deter them from using it?



FEATURE TECH

How ChatGPT and similar AI will disrupt education

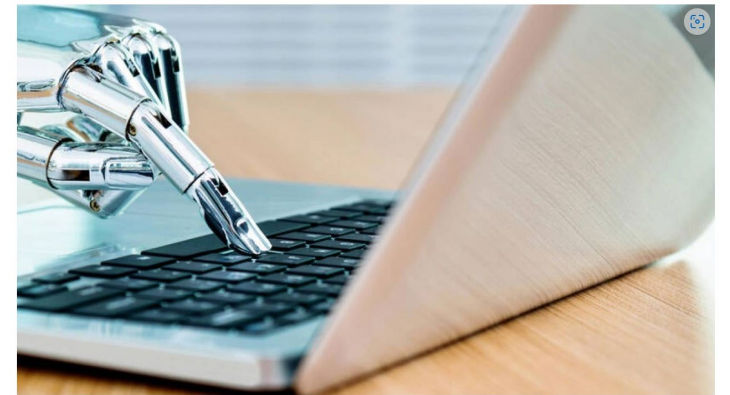
Teachers are concerned about cheating and inaccurate information



Is ChatGPT a threat to education?

February 2, 2023

Iqbal Pittalwala, UC Riverside



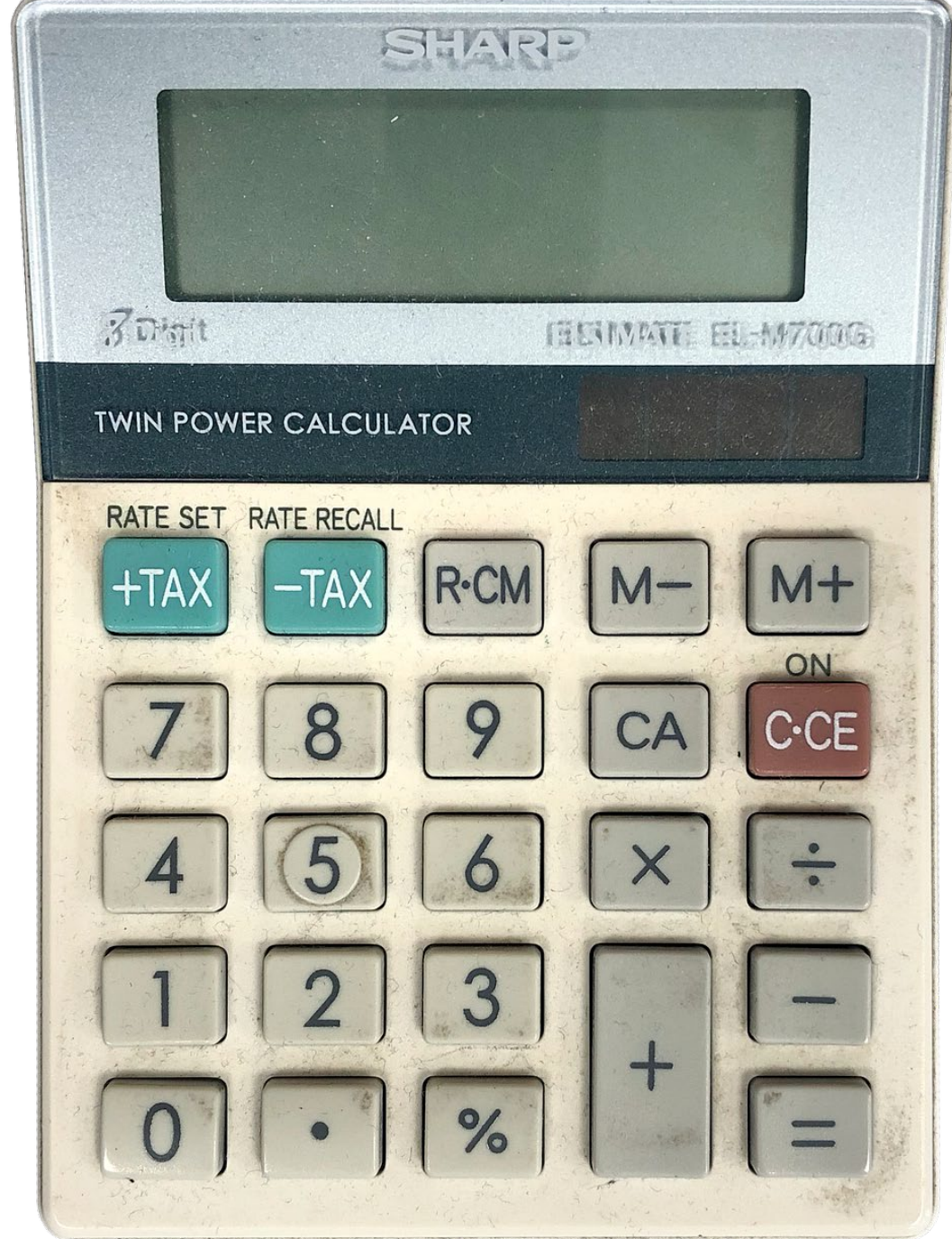
Credit: iStock/baona



Chance or a threat?

Let's go to a short journey to the past...





Calculator


- In the 1970s calculators slowly began to enter the classroom
- Fears: students' computational abilities would be ruined, students would become too reliant upon machines, students wouldn't learn how to estimate, they wouldn't learn from their errors...
- In some states their use has been prohibited until 1990s

A person's hands are shown interacting with a tablet computer. The tablet screen displays a grid of colorful images, possibly a gallery or a collection of educational materials. The background is slightly blurred, showing what appears to be a classroom or office environment with a desk and other equipment.

Computers, www, Smartphones, Tablets,

...

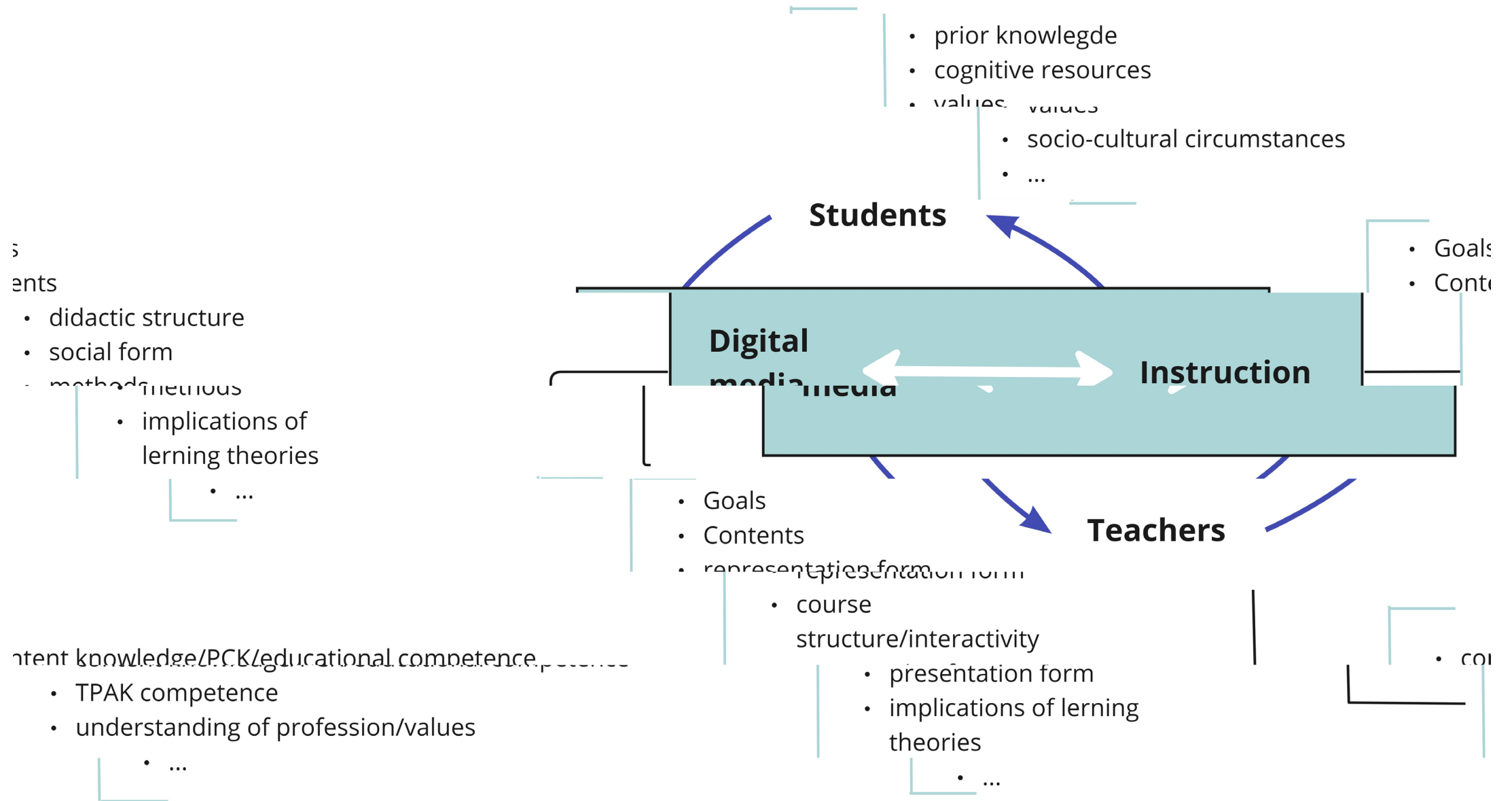
- Some of the hope and some of the panic about calculators have shifted to other computing devices
- “Students will not be able to read.”
- “Smartphones are distraction for students in a classroom.”
- “Students will use these devices to cheat.”



How effective are digital media in the classroom?

- It depends...
- The effects of digital media in the classroom can only be discussed in the context. (Herzig 2014)
- There is sufficient empirical evidence for aspects of the use of digital media in schools that are beneficial to learning, but **it is not possible to generalize these results**. No general statements can be made about the effectiveness of specific devices nor about individual media offerings, specific groups of students, or subject cultures.
- Metastudies: only a marginally positive effect (if at all) in terms of students' learning performance compared to analog approaches

Effects of digital media in the classroom - influencing factors



Then why are
we talking
about it?





A few thoughts from me

1. Training media competence (BITKOM 2011; Reinmann und Häuptle 2006)
2. Training self-regulation (Schulz-Zander 2005)
3. Time and location independent
4. Possibility of giving equal opportunities
5. Authenticity of context, interest, motivation...
6. Possibility for more interaction and communication
7. An incredible number of possibilities are available
8. ...
9. „Who does not shape will be shaped.“



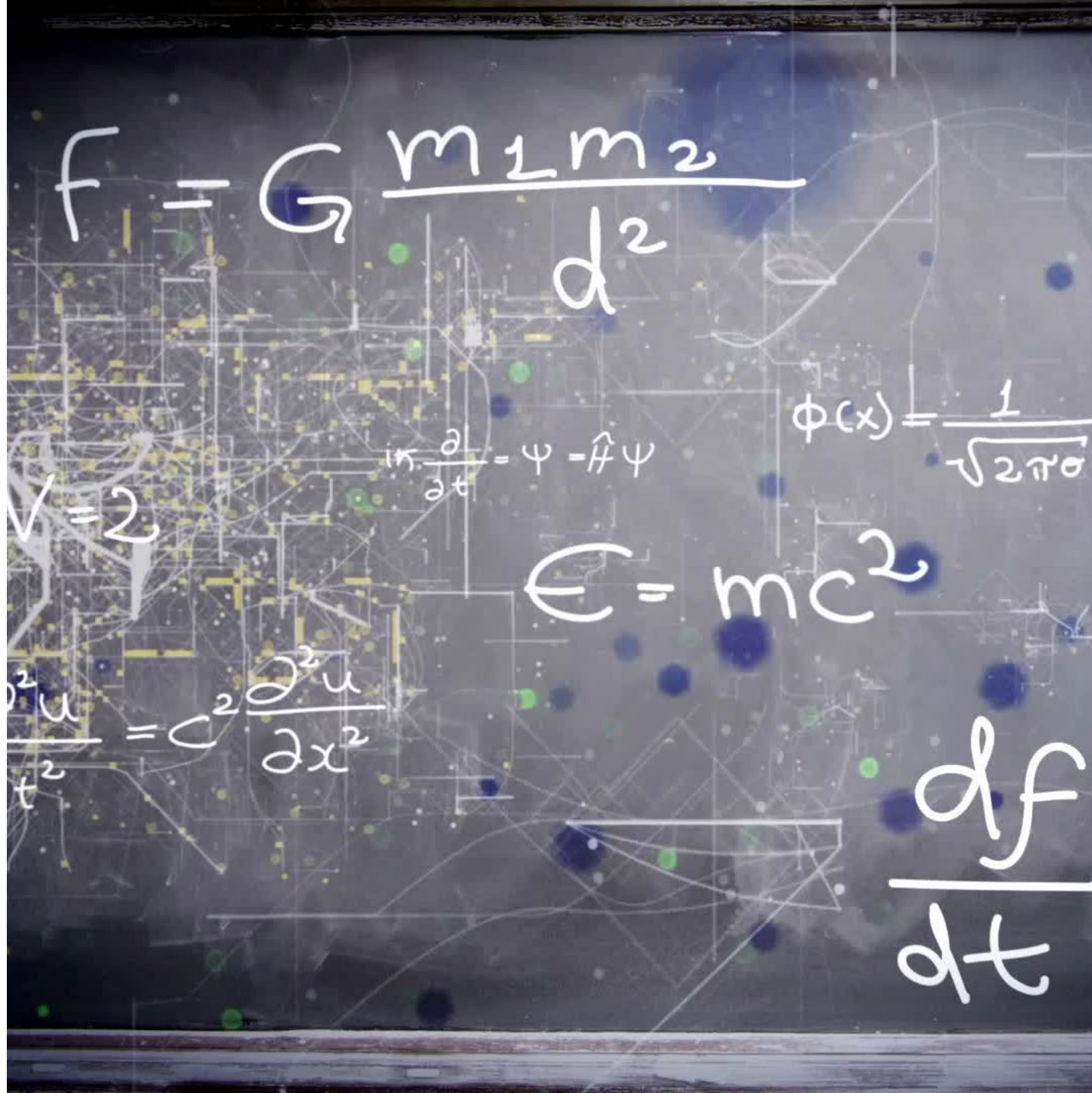
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„Who does not shape will be shaped.“

- In addition to a technical point of view, to make decisions, stakeholders need to move from short-term reacting back to active, sustainable shaping/decision making.
- But how can decision-makers act sustainably without a basis for their decisions that will last for the coming years?
- In addition to a technical understanding of the opportunities and risks, a sound basis for decision-making also requires an understanding of the sustainable consequences of all our actions and inactions.
- Our actions/inactions need to be based on the research.

Possibilities and challenges in physics courses at university level

- Before COVID-19
- During COVID-19
- After COVID-19
- Possible future developments



Before COVID-19

- Lecture capture – recording of live lectures:
 - Connection with student end of course performance is not clear (Lindsay, 2021)
 - In some studies: smaller attendance rate of lectures that were recorded (Morris 2019)
 - In flipped classroom setting students preferred to attend live lectures while in non-flipped classroom settings they found that lecture captures were helpful (Wood 2018)
- Factors predicting students' online learning achievement: two factors are positive predictors of learning achievement measured through the course grade and these are “selfdirection” and “beliefs,” where self-direction stands for good self-organization skills and beliefs stands for “general beliefs about online learning” (Bernard et al., 2004)
- E-learning in physics: The students in online course at MIT had a normalized gain slightly higher than typical values for a traditional course, but significantly lower than typical values for courses using interactive engagement pedagogy. (Colvin, 2014)
- Remote labs, online quizzes and homework, simulations (Finkelstein 2005)
- Smartphones and smartphone sensors (Staacks – PhyPhox, 2018)

Research on synchronous and asynchronous e-learning

Cognitive and personal dimensions of E-learning (Hrastinski, 2008)

Asynchronous e-learning

Synchronous e-learning



Cognitive Participation

Increased reflection and ability to process information

Content-related communication is supported

More time to comprehend message, immediate answer is not expected

Personal Participation

Increased arousal, motivation and convergence on meaning

Other types of communication are supported: planning of tasks and social support

Receiver's reaction to a message is monitored, which motivates receiver to read and answer the message

During COVID-19

Sudden shift to e-learning at schools and universities worldwide in March 2020 due to COVID-19 pandemic

New situation for most of instructors and students

Lot of decisions about the lesson formats and digital tools

Implications for the future physics courses?



**TECHNISCHE
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DRESDEN**



**GEORG-AUGUST-UNIVERSITÄT
GÖTTINGEN**



**universität
wien**

Participating universities and researchers

- TU Dresden: Dr. M.-A. Geyer
- Universität Göttingen: M. N. Dahlkemper, Prof. Dr. Pascal Klein
- TU Kaiserslautern: Dr. S. Küchemann
- Universität Wien: Jun. Prof. Dr. L. Ivanjek
- Universität Zagreb: Prof. Dr. A. Susac, Dr. K. Jelcic



**TECHNISCHE UNIVERSITÄT
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Research questions

- What is the relationship between perceived learning effectiveness during the COVID-19 summer term and the various behavioral aspects that are important in digital teaching?
- Which course formats during unexpected e-learning situation did students prefer and why?
- What formats were used to establish online problem-solving sessions, and how have they been rated by the students in terms of effectiveness?
- What are students' experiences with the online laboratory courses for prospective physics teachers during the COVID-19 lockdown?
- Which activities do students found helpful for their learning?
- What are the implications for the future – what can we learn from this situation and which online formats do students want to preserve even after COVID-19 Pandemic?

Research methods

18 semi-structured interviews

Questionnaire with 246 technical data fields
which were divided into 13 subtopics

Interviews

- 33 – 94 minutes
- **Personal situation of students;** accessibility of technical equipment and internet connection and online learning environment: Please describe how you cope with online teaching in the current situation.
- **Advantages and disadvantages of different course formats:** What advantages and disadvantages do you see with the different forms and formats of online teaching (synchronous, asynchronous)?
- **Preferences for synchronous and asynchronous courses and the reasons:** Which course formats (synchronous or asynchronous) do you prefer? Would you rather prefer more or less offers from one of the course formats? Explain.
- **Implications for the future courses after COVID-19 pandemic:** Which course elements from the online courses would you like to keep even when the courses at university are possible?
- **Lab for prospective physics teachers:** Describe briefly how the lab took/takes place. Do you feel you can prepare the school experiments well from home? Compare your performance of experiments from home (experiments with everyday materials, simulations, smartphones...) and at the university. What advantages and disadvantages do you see for your teaching career?

Questionnaire development

- Based on the common literature for evaluating online teaching and learning, we identified several aspects that were considered relevant for physics student learning during COVID-19 pandemic:
 - evaluation of synchronous and asynchronous activities
 - students' attitudes toward online learning
 - communication abilities
 - expected learning achievement
 - technical and social aspects
 - self-organization abilities
 - implication for the future physics courses
 - organization of recitations
 - organization of labs for future physics teachers
- All items were assessed using a 4-point Likert-type scale

Data collection and sample

Interview sample

	Number of interviewed students	Female (%)	Semester
Dresden	4	50%	4 th , 8 th , 9 th and 10 th
Göttingen	3	66,6%	4 th , 6 th and 17 th
Kaiserslautern	1	0%	1 st in Master
Wien	4	25%	4 th , 5 th , 6 th , 7 th
Zagreb	6	66,6%	2* 2 nd , 6 th , 2 * 8 th , 10 th
SUM	18	50%	

Questionnaire sample

	Total sample	Male (%)
Dresden	114	73 (64.0)
Göttingen	232	144 (62.1)
Kaiserslautern	9	5 (55.6)
Wien	138	85 (61.6)
Zagreb	85	45 (52.9)
SUM	578	352 (60.9)

participation rate 21.4% (from 11% (Dresden) to 57% (Zagreb))

Data analysis

Interviews



All interviews were transcribed and analysed in their original language

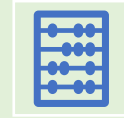


Qualitative content analysis, Kuckartz; using software for qualitative data analysis MAXQDA



Based on the interview questions, deductive categories were first generated and then refined by creating inductive categories

Questionnaire



Psychometric validation of instrument structure using a confirmatory factor analysis



The internal consistency of a component is measured by the reliability coefficient Cronbach's α



Cronbach's α indicates how well the items build the same construct (Cronbach's α can range from 0 to 1 - values above 0.7 are considered reliable for group measurements)

Description of the scales that were used for all students

Description and psychometric characteristics of the scales that were used for all students				
Scale	# items	Sample item	Reliability (Cronbach's alpha)	Mean score \pm standard deviation (Percentages)
Synchoronus courses	6	Synchronous activities help me to understand the learning content more than asynchronous activities.	0.83	2.86 \pm 0.63
Self-organization abilities in general	5	In my studies, I am self-disciplined and I find it easy to set aside reading and homework time.	0.76	2.97 \pm 0.57
Self-organization abilities during COVID 19-semester	6	Not being at university hinders me from studying*.	0.77	2.41 \pm 0.67
Environment	2	I have a quiet space where I can participate in video conferences unhindered.	0.90	3.11 \pm 0.76
Face to face preferences (vs. online)	6	Classroom instruction helps me to understand the physics concepts better than in online courses.	0.75	2.84 \pm 0.80
Learning achievement	7	I am certain that I will complete the online physics courses with good grades.	0.88	2.56 \pm 0.66
Communication	8	It is easy for me to establish contact with other students during Covid-19 pandemic.	0.88	2.19 \pm 0.57

*Negative statements were reversed for the analysis.

Selected
results



Perceived learning effectiveness and various behavioral aspects

Students' perceived learning success is positively correlated with high abilities of self-organization in general, with self-organization in this specific situation, with access to a study-friendly environment, students' attitudes toward online learning and the ability to communicate with peers and lecturers.

TABLE III. Correlation analysis. Only significant correlations (Pearson's r ; $p < 0.003$) are presented.

	Scales				
	1	2	3	4	5
(6) Learning achievement	0.33	0.63	0.32	0.58	0.48
(1) Self-organization general	1	0.37	0.17	n.s.	0.20
(2) Self-organization COVID-19	...	1	0.33	0.62	0.48
(3) Environment	...	...	1	0.19	0.28
(4) Attitudes toward onl. learn.	...	...	...	1	0.41
(5) Communication	...	...	...	...	1

P. Klein, L. Ivanjek, M.N. Dahlkemper, K. Jeličić, M.-A. Geyer, S. Küchemann, A. Susac, Studying physics during the COVID-19 pandemic: Student assessments of learning achievement, perceived effectiveness of online recitations, and online laboratories, Phys. Rev. Phys. Educ. Res. 17 (2021).




Different course formats

Synchronous and asynchronous course formats



Recommendation from PhysPort platform

- *“Recognize that not all your students will be able to attend synchronous online classes due internet access, connectivity, scheduling, health, and family situations. Some platforms allow participants to call in via phone, which allow them to hear and participate in audio conversations, but not see slides, screenshare, or video. Find ways for students who can't connect in real time to still participate (e.g., by making recordings available after class), or consider not running synchronous classes at all: asynchronous learning can be much more equitable for students with different levels of access, health and privilege. These are also good things to keep in mind when you are teaching in-person classes”.*
- www.physport.org



Synchronous and asynchronous course formats

- Results based on interviews:
- Eight interviewed students preferred synchronous formats, two students preferred completely asynchronous formats and eight students think that the mixture of the both is the best solution
- Five students said explicitly that they would like to have more synchronous formats
- Eleven of interviewed students attended synchronous formats regularly. The main reasons: requirement from the instructor, regular day structure, not to skip something, easier to learn, to ask questions and hear questions from others, because instructors apply lot of effort.
- Five of interviewed students work through all asynchronous tasks and materials. The motivation: interest in the topic and the desire not to waist the semester and to be prepared for the exams at the end.

Advantages of synchronous physics courses

Advantages of synchronous physics courses	Examples of student quotes from the interviews	Frequency
Possibility to immediately ask questions	“You can ask questions when something comes up. And you don’t always have to write e-mails afterwards. So you can address the problems right away, which is very helpful.” [TUD03]	10
Interaction with other students and the feeling of community	“And a big factor is simply also this social component, because you sit at home, you have little contact with your fellow students, because you don’t know every student and when you only hear someone or see someone, it’s simply ... you have that feeling again: “okay, I’m not the only student in the world who might be struggling right now. That’s certainly the big advantages that I see.” [UV02]	8
Daily structure	“So I think the synchronous formats are more helpful because they give a regular schedule to the students, and so to me. And so I can better plan my week, which I think makes life a little bit easier for all the people who are maybe not so good with time management, I think.” [UV02]	5
Feeling to understand more and to get the information that are important	“It is useful that some things that we cannot comprehend alone are repeated, instructor emphasizes them and then we know that we need to be careful about them. Especially when instructor explains the problems then we know that this is essential for this unit, but not only now, but also for the next chapter – on this way we know which things are important for us.” [UZ02]	4
Social pressure as a motivation factor	“For me the synchronous classes where we see each other are better, for example this lab course once a week where I know that we will see each other via Zoom and that I that I need to fulfill my assignments – that is what motivates me.” [UZ01]	3
Similarity to the “normal” course	“But in my opinion one is more dynamic in synchronous courses and everything is a bit more interactive and it is more like natural learning.” [UV03]	3

Disadvantages of synchronous physics courses

Disadvantages of synchronous physics courses		Frequency
Technical difficulties	<p>“Video conferences are always like... It’s just kind of exhausting. Fifty percent of the people don’t have suitable microphones for it, which is understandable. And that’s okay. Nobody can do anything about it. Then, simply because of the technical latency that exists, people are constantly talking into each other. Or there is just a hard moderation, which then again also somehow brakes the discussion. So the technical limitations that are just inherently there make the whole thing a bit idle, from my point of view.” [TUD02]</p>	3
Insufficient (poor) communication	<p>“You simply don’t have this personal, human interaction in a room.” [TUD02]</p>	2
Insufficient activation	<p>“In synchronous classes instructor does not have that strength to get us to participate so much. You turn off the microphone and it’s over and no one can make you talk. So often there are these uncomfortable silences.” [UZ]</p>	1
Data protection	<p>“I think the big disadvantage of the synchronous is just, for data protection reasons, that the recording is not possible or only with difficulty.” [TUD04]</p>	1
Units are dragged	<p>“That’s just the time factor, especially now via the online communication channel here, many things drag on extremely long, where you might think you could deal with it a bit faster, etc. So that you sometimes just really, just directly said, listen to fellow students who ask about things, where you just think: “that’s obvious”. So that can get a bit annoying sometimes with time. But ... yes, you just have to accept it sometimes.” [UV03]</p>	1

Advantages of asynchronous physics courses

Advantages of asynchronous physics courses	Examples of student quotes from the interviews	Frequency
Flexible time management	“But it's also the case that I find it quite pleasant to organize things by myself. Because I get up relatively early and this semester I have a lot of courses in the afternoon and my attention threshold has already dropped by then. So I find it better if I can do something for the university right at seven o'clock in the morning, when the course instructors might not even be awake yet.” [UV04]	10
Possibility to watch videos in the own pace (slower, faster, more times)	Recorded lectures are great because the recording can be accelerated, slowed down, stopped, but again if something is not clear, then a mail must be sent to the professor.” [UZ05]	4
Less distraction through other students	“And you can probably concentrate a bit better when watching the videos, because there's no one sitting next to you to chat during the lectures.” [TUD03]	1

Disadvantages of asynchronous physics courses

Disadvantages of asynchronous physics courses		Frequency
Flexible time management	“The problem is to get up in the morning and go to work, especially if the lectures are recorded, then you postpone, you postpone... you end up at 10 in the evening you watch..”[UZ06]	5
Missing possibility to immediately ask a question and get the answer	“The only disadvantage I see with the asynchronous ones is that you can't ask any questions.” [TUD04]	4
Missing interaction	“When you're sitting all alone in the middle of the night in front of a video that someone has recorded. I find that you lose even more contact, that means the connection.”[TUG01]	3
One need to do everything alone	I need to do everything on my own. A lot of reading, digging and bringing together different documents that the instructors upload. They give us 4-5-6 documents for one lecture and say read this. And then it takes a lot of time to go through it all, to concise and to make one useful document that will contain all this 6 – and that takes a very long time.” [UZ]	1
Materials not extensive enough – missing understanding	“Or that I sometimes do not have enough materials and I have the problems understanding it and thus have to do even more background work myself.” [UV04]	1
Only lower limit, no highlights	“But you don't look beyond the horizon and you do not get new inputs that are very interesting and that actually make up the highlights of units. And it is then really a certain minimum that must be fulfilled. But no more and no less.” [UV03]	1



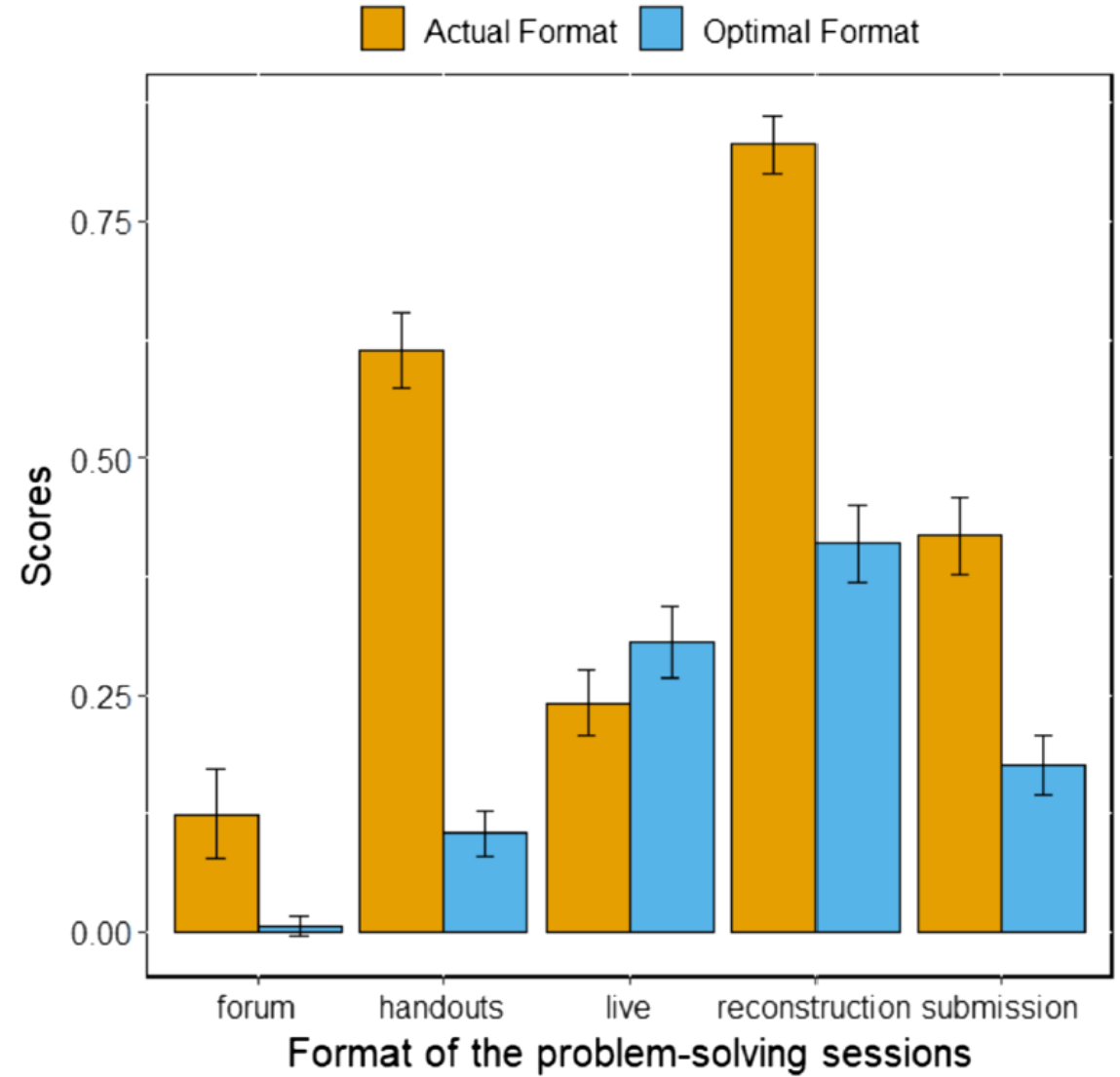
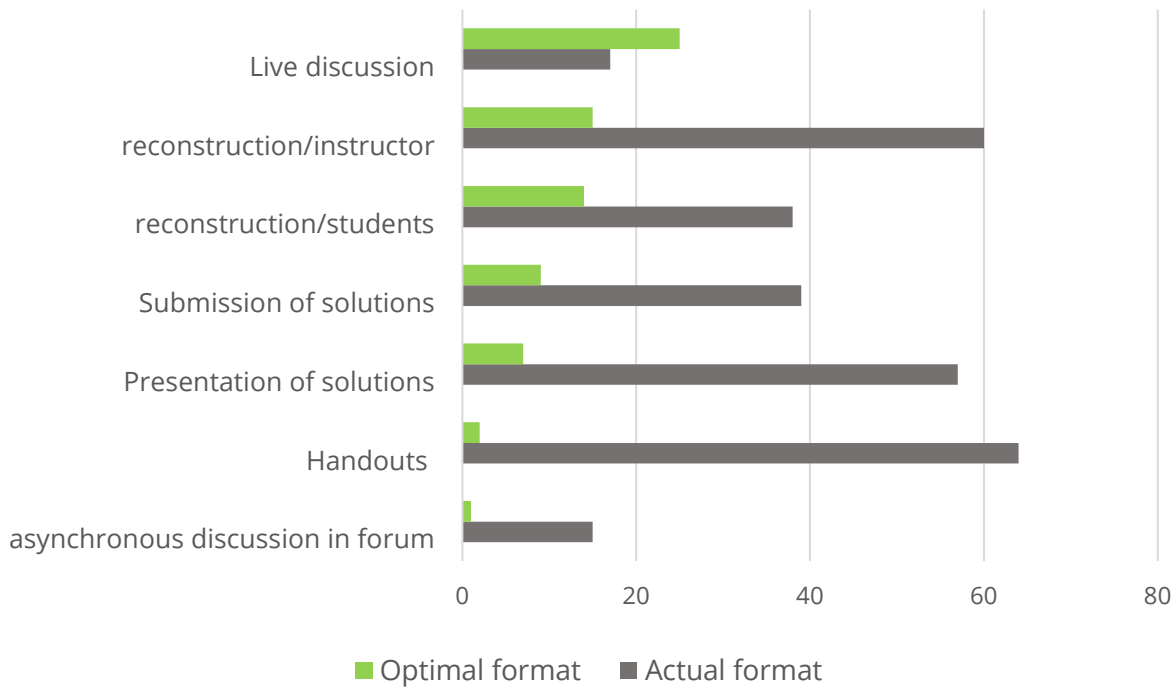
Seminars and
problem
solving
sessions

Online problem- solving sessions

- 401 datasets from students who attended recitations, 287 of which were related to introductory physics courses with large audiences (>30 students)
- Based on the student interviews, different online formats of the recitations were identified that could be assessed in terms of the following aspects (true or false):
- **submission:** The students' solutions were submitted, corrected by the tutor, and discussed in an online meeting
- **reconstruction:** The solutions were reconstructed during a live online session in real time
- **live:** Exercise sheets were solved live online and discussed in groups
- **handouts:** The solutions to the exercise sheets were handed out to the students as text or as a video (worked-out solutions)
- **forum:** Forums were used to discuss exercise sheets without time constraints.

Formats of the online recitations that students experienced term and judgments about optimal recitation

TU Dresden, N = 92



Labs for
future
physics
teachers

Interviewed participants		Participants partaking in the questionnaire	Faculty the participants attend
Total	Attending lab		
4	3	28	TU Dresden
4	4	40	University of Vienna
4	3	31	University of Zagreb

positive aspects seen by students

free time management

fun while conducting experiments

amazed that simple equipment worked well

working with a partner

fair evaluation

advantages for being a teacher later:

- new options
- creativity
- more flexible
- connection to everyday life

negative aspects seen by students

more time invested

no suitable equipment

less precise measurements

fewer (less interesting) experimental options

fewer/no discussions with fellows and/or instructor

no understanding

disadvantages for being a teacher later:

- less experimental practice
- no gains for being a teacher later

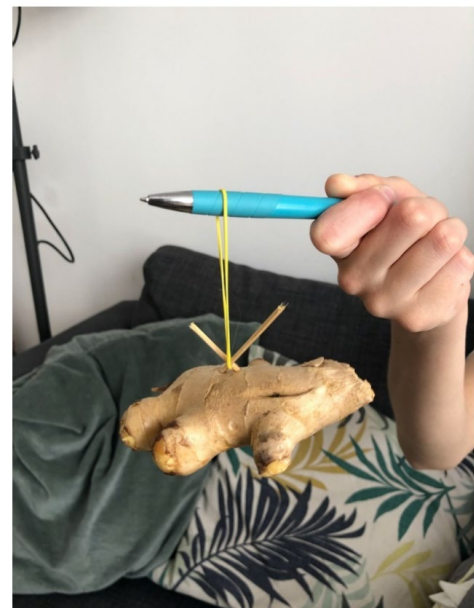
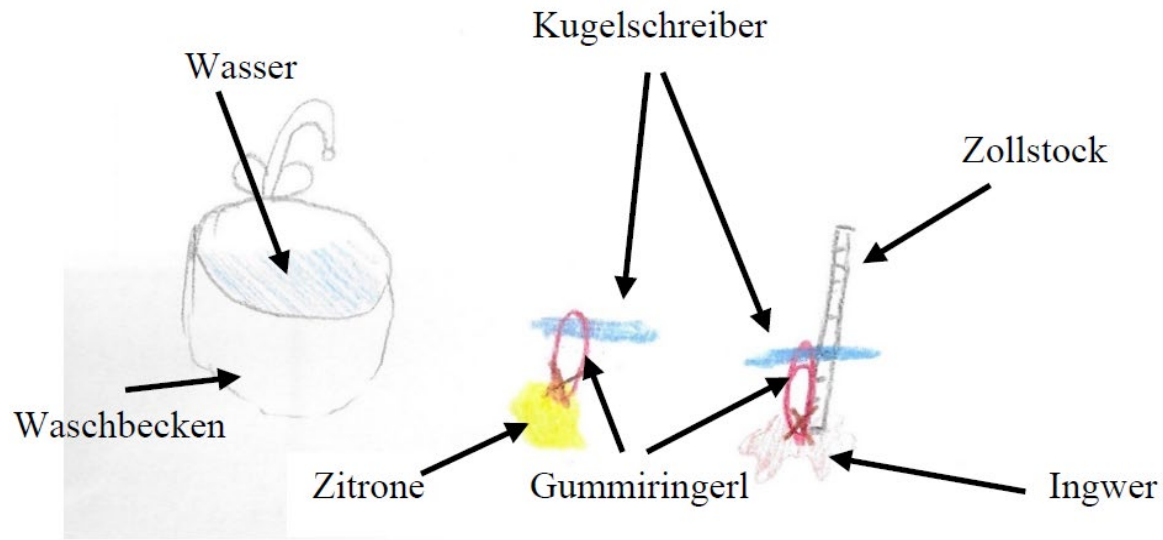
Positive and negative aspects reported by the interviewed students who were attending the adapted lab courses

K. Jelacic, M.-A. Geyer, L. Ivanjek, P. Klein, S. Küchemann, M. N. Dahlkemper, and A. Susac, *Lab courses for prospective physics teachers: What could we learn from the first COVID-19 lockdown?*, *Eur. J. Phys.* **43**, 055701 (2022).

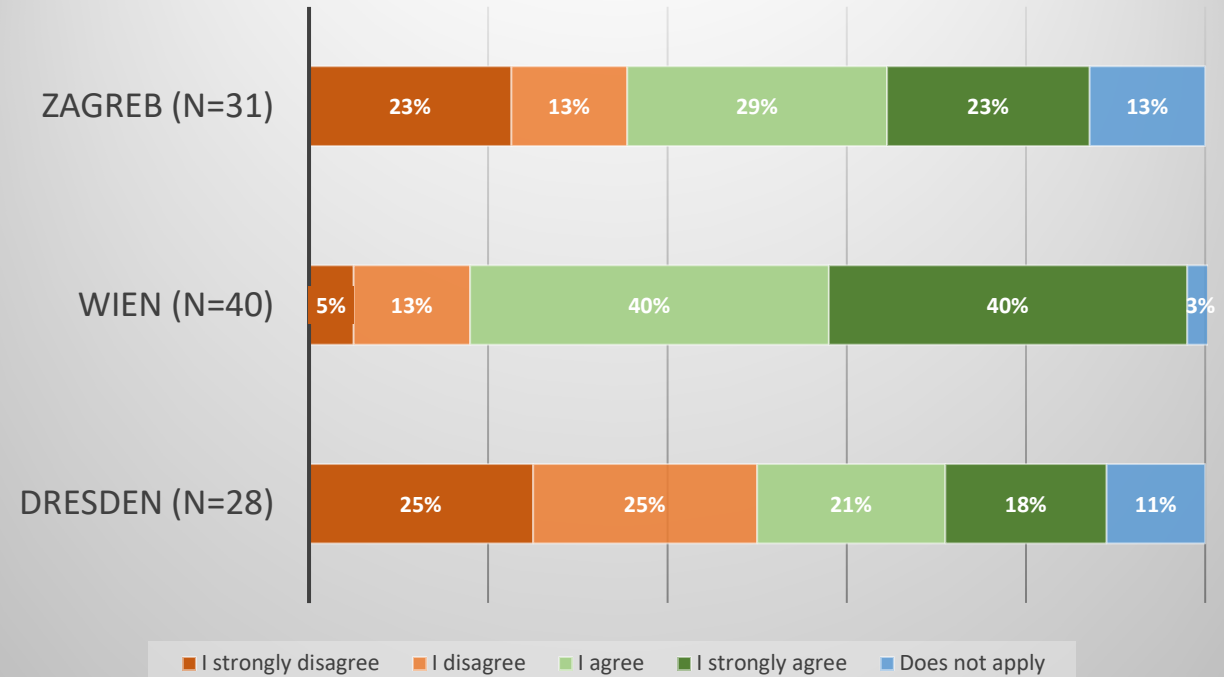
Student quotes

- ***“One becomes more creative anyway, perhaps. So, one sees what would be possible and what one would never have thought of because [at university] one walks straight to the cupboard and takes out the great equipment. And the connection with the everyday live is promoted even a bit more. So, no child has a physics experiment cabinet at home, no average child. But a kitchen sponge or whatever, everybody knows that. And you start thinking about that much more immediately and then you can transfer that. There, I see already a large advantage, too.” [UV03]***
- ***“And other than that, yes, the disadvantage is that you don't really handle the equipment there. I'm just dealing with household objects now.” [TUD03]***
- ***„...in some experiment that I have to do at home, we're not always sure what we need to get. I mean, when we were doing optics experiments, those holes in aluminium foil, I really didn't know in advance what I need to see. And, I was getting different patterns with lamps from different mobile phones and didn't really know what I had to get and that was complicated. If we were in the real lab...I don't know...I would call you or the assistant and then he would explain this to me. Now, I had to struggle myself. That is complicated for me when I find myself in such a situation. “ (UZ03)***

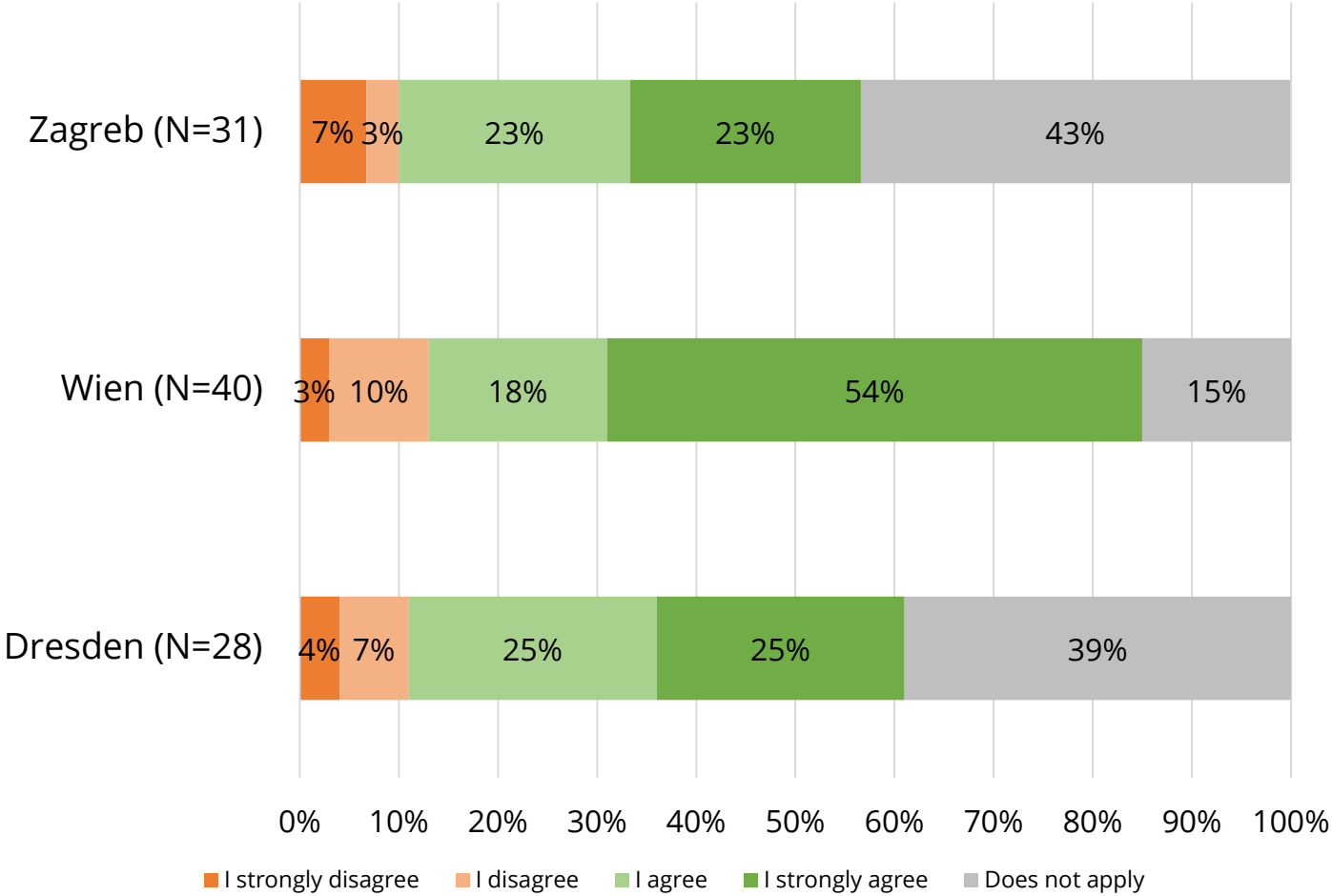
Creativity



Conducting experiments from home increased my creativity.



**Online consultations with the instructor
BEFORE conducting experiments were helpful.**

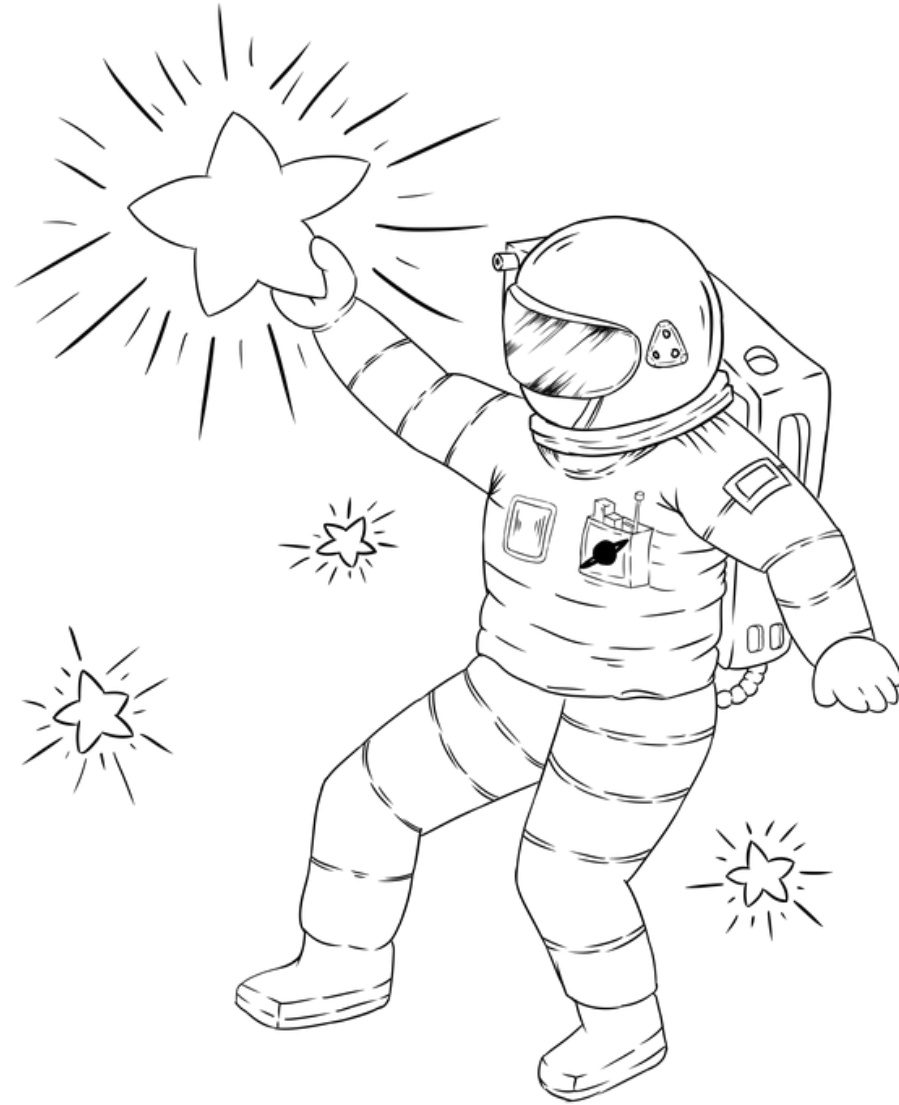


Online consultations

What course elements students find helpful?

Course elements	%
1. Recorded videos from instructor	82%
2. Lectures at university	81%
3. Conducting experiments at university	77%
4. Synchronous online lectures	68%
5. Synchronous online Q&A sessions	66%
6. Live video stream from lectures	59%
7. Videos from third parties	56%
8. Group work and discussion with other students	51%
9. Uploaded presentation (without audio)	40%
10. Conduction experients from home	23%

Implications for future



Implications for future physics courses

Course elements that students want to preserve in future – results from interviews

Course elements	Frequency	
Use of learning platforms: uploaded lecture notes	7	<i>"So I think it's very nice that people are now using OPAL more actively. And I know that many find OPAL a bit ambivalent, but basically, I find it quite practical. And I would like to see this maintained in the future as it is now. In other words, that all materials that are relevant for the course are always available." [TUD02]</i>
Uploaded lecture videos	6	<i>"Yes, one thing that I can think of is that lectures videos are uploaded. ... But I don't think that this should replace a classroom lecture, but if they are simply offered in addition to it, I think that would be totally good." [UG03]</i>
Nothing	4	<i>"So in principle, if presence is offered again, I want to be present at the university, because I study at face-to-face university and not at online or distance learning university. That's why I prefer presence only." [TUD3]</i>
Online question and answer session	3	<i>"Maybe an online Q&A session, I would find that quite exciting, because the this is not mandatory, and one skips that. You just don't go there because it's not mandatory, but it would be good to go. If you would offer that online, it would be much easier from the distance. ... and it would be easily accessible from anywhere and that would often be very exciting.." [UV03]</i>
Forum discussions	2	<i>"In any case, the forum, in general a question forum, because there are students who are perhaps somewhat shy and do not dare to ask questions or write an email or something like that. Or who might need time to thaw a bit and then dare to ask questions sometime later." [UV03]</i>
Some courses with smaller number of students as e-learning course	1	<i>"Courses with small number of participants, I believe that the advantages, i.e. no travel to university, to complete the online class at home and therefore not one hour at the university, then again one hour at home, one hour at the university... That this is an advantage for the small courses with few students and that should be continued. Or at least a mixture of both." [TUD03]</i>

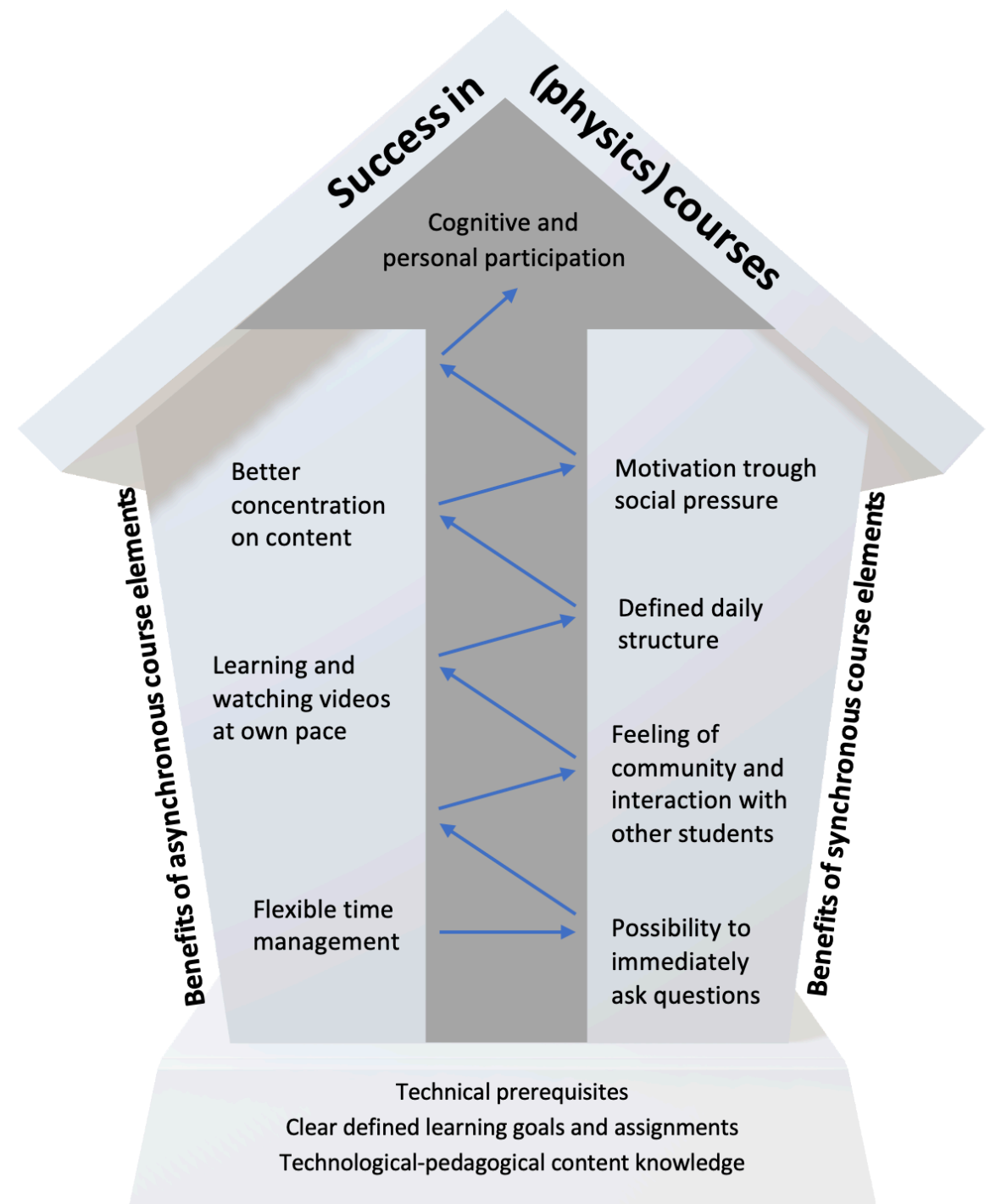
Implications for future physics courses

Course elements that students want to preserve in future

	Learning materials uploaded in the learning platforms (scripts).	Recorded video of the lectures in addition to classroom lectures.	Synchronous online consultations in addition to classroom lectures.	Recorded video of the lecture as replacement for classroom lectures.	Synchronous online lectures in addition to classroom lectures.	Conducting experiments at home as replacement for some lab experiments.	Synchronous online lectures as replacement for classroom lectures.
Dresden	97%	73%	48%	26%	22%	15%	13%
Göttingen	93%	78%	31%	18%	22%	9%	9%
Vienna	92%	76%	49%	26%	39%	23%	27%
Kaiserslautern	78%	67%	33%	11%	22%	0%	22%
Zagreb	89%	76%	46%	14%	27%	20%	13%

Success in (online) physics courses

L. Ivanjek, P. Klein, M.-A. Geyer, S. Küchemann, K. Jeličić, M. N. Dahlkemper, and A. Susac, Studying physics during the COVID-19 pandemic: Student perceptions on synchronous and asynchronous course formats and implications for the future Phys. Rev. Phys. Educ. Res. **18**.



Personal experience and tools used

- Synchronous meetings: Zoom
- Whiteboards: Padlet, Miro Board, Mural
- Quizzies: Mentimeter, Socrative
- Producing learning videos/lecture capture: OBS
- Simulations: Phet Colorado
- Interactive screen experiments: FU Berlin
- Smartphone experiments: PhyPhox, Vernier Video Physics, Sony Motion Shot

Conclusion

- The most common reported advantages of synchronous course elements were the possibility to immediately ask questions, feeling of community and interaction with other students, and defined daily structure
- The most common advantages of asynchronous course elements were flexible time management and the possibility to watch videos at their own pace
- Different people/target groups also have different preferences - also with regard to online vs. face-to-face classes

Recommendations for the future online and in-person physics courses:

- Formulate assignments and learning goals for the course as clear as possible.
- Use synchronous course formats (online or in classroom) to cognitively activate students and engage them in discussions using quizzes, group problem solving sessions, group discussions, tutorials, and group projects. Digital boards can be used to collect group results and monitor group progress.
- Provide collaboration tools for students to exchange their ideas or ask questions.
- Use asynchronous course formats to expose students to more complex content. Upload relevant information to learning platforms to make them available for all students and to provide them with the same opportunities for learning. In order to increase student engagement with asynchronous course formats consider giving incentives for completing asynchronous tasks
- Ensure a good balance between synchronous and asynchronous course activities. Supplement live lectures with the lecture recordings to make them available to students after the lectures or even before if you are using flipped classroom methods.

Post-COVID times

Hybrid physics courses at
universities

The primary factors for successful and equitable e-learning



(1) Professional training is crucial and has been shown to improve teachers' acceptance of technology for physics instruction.



(2) Real-time tech support is essential to successful instruction.



(3) Participation in small-group collaborative learning correlates with deeper learning, increased teamwork, and can increase students' sense of community.



(4) Mechanisms to directly combat high dropout rates for e-learners must be developed, including communication with lower-achieving students.



(5) Inequalities should be considered when implementing e-learning, especially their effect on access to technology.

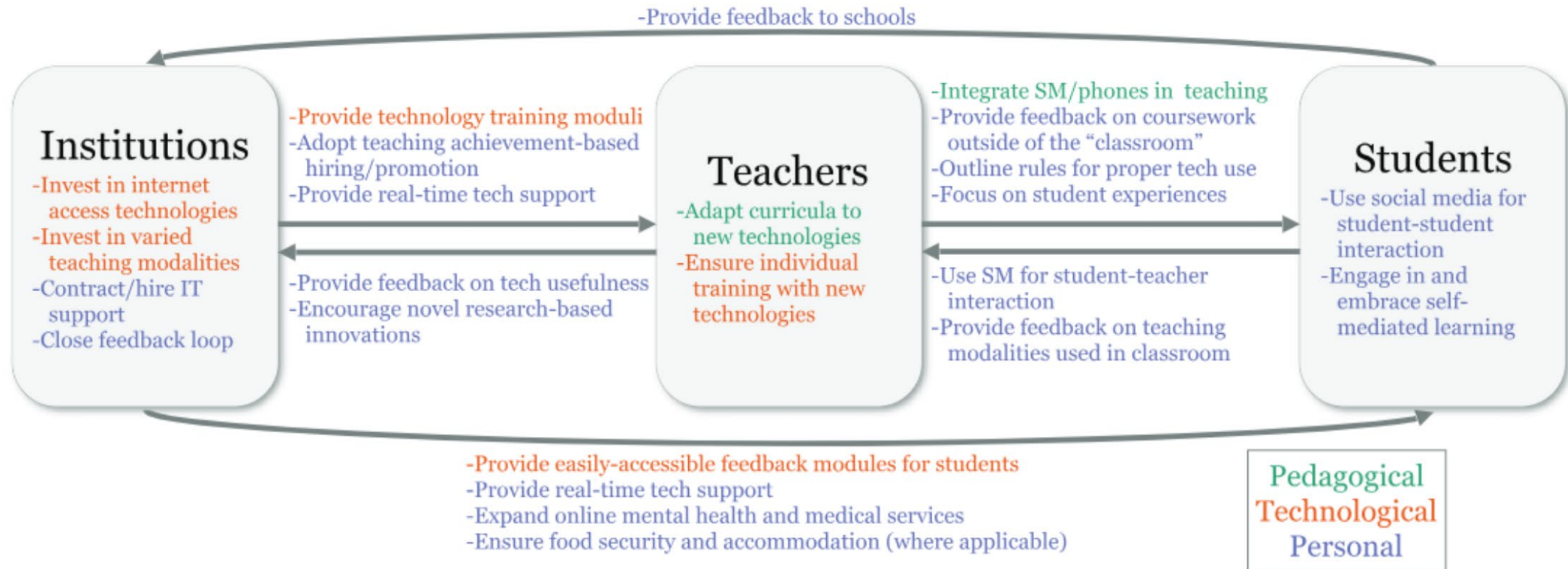


Fig. 1. (Color online) A graphical representation of support mechanisms for improving e-teaching and e-learning of physics at the university level.

Hybrid physics courses - Why?

Corona
circumstances –
illness

Giving equal
opportunities

Individualisation

Important prerequisites for interactivity

- Exercises and seminars with lower numbers of participants (N=16)
- Students on site bring their own computer or tablet (in case of emergency it is also possible to use a cell phone) and they switch on in the Zoom meeting (without sound!!!)
- An online whiteboard is used to collect the results - two groups of participants "communicate" via this whiteboard.
- Students on site work in small groups and students online in breakout rooms/or students on site build a group with students at home
- All important links and surveys are communicated either in chat or with QR code

Implementation of group work

- Padlet, Miro Board oder Mural Board – make ‚live‘ tracking of group work in break-out rooms and make the synthesis easier

Kärtchentisch 2

Skizze

Stromstärke

Spannung

Widerstand

Anwendungen

Verhalten von Glühlampen

Gleichungen

Reihenschaltung

Parallelschaltung

Die Stromstärke ist an jeder Stelle der Stromkreis gleich groß.

Die Teilspannungen addieren sich zur Gesamtspannung.

Die Teilwiderstände addieren sich zum Gesamtwiderstand.

Die Teilströme addieren sich zum Gesamtstrom.

Die Leistungsaufnahme der Teilwiderstände addieren sich zum Gesamtwert.

Sicherungsausrüstung, Sommergeräte

Haarstrahler, Mischschaltkasten

Wenn mit einer Glühlampe bei gleicher Leistung die andere länger leuchtet.

Wenn mit einer Lampe bei gleicher Leistung die andere länger leuchtet.

$I_1 = I_2 = \dots = I_n$

$U_1 + U_2 + \dots + U_n = U_{ges}$

$R_1 + R_2 + \dots + R_n = R_{ges}$

Parallelschaltung

Wenn man eine Glühlampe austauscht, werden die anderen länger leuchten.

Die Stromstärke ist an jeder Stelle des Stromkreises gleich groß.

Wenn man eine Lampe bei gleicher Leistung die andere länger leuchtet.

Die Teilspannungen addieren sich zur Gesamtspannung.

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$I_1 + I_2 + \dots + I_n = I_{ges}$

$U_1 = U_2 = \dots = U_n$

$\frac{1}{R_1} + \frac{1}{R_2} + \dots + \frac{1}{R_n} = \frac{1}{R_{ges}}$

Reihenschaltung

Verhalten von Glühlampen

Skizze

Die Stromstärke ist an jeder Stelle des Stromkreises gleich groß.

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Aufgabe 1 - Gruppe 2

Die Abbildung zeigt zwei Wellenfronten, die durch eine Punktquelle erzeugt werden.

A. Bestimme den Abstand zwischen den Quellen. Drücke deine Antwort als Vielfaches der Wellenlänge λ aus.

1,5 Lambda

B. Markiere in der Abbildung A mithilfe unterschiedlicher Farben die Stellen im Bild, an denen zum dargestellten Zeitpunkt:

- Die Auslenkung der Wasseroberfläche gleich Null ist (schwarze Farbe).
- Die Auslenkung der Wasseroberfläche maximal oberhalb der Gleichgewichtslage ist (rote Farbe).
- Die Auslenkung der Wasseroberfläche maximal unterhalb der Gleichgewichtslage ist (grüne Farbe).

C. Die Abbildung A, die wir bisher benutzt haben, und die von dir dort markierten Stellen beschreiben die Wasseroberfläche zu einem bestimmten Zeitpunkt. **Wähle einen Punkt** in der Abbildung aus, an dem ein Wellenberg auf einen Wellenberg trifft, und betrachte ihn. Wie wird sich die Auslenkung der Wasseroberfläche an diesem Punkt mit der Zeit verändern?

Betrachte nun einen Punkt, an dem ein Wellenberg auf ein Wellental trifft. Wie wird sich die Auslenkung der Wasseroberfläche an diesem Punkt mit der Zeit verändern?

Es **wechselt sich Minimum und Maximum der Auslenkung** ab.

Betrachte nun einen Punkt, an dem ein Wellenberg auf ein Wellental trifft. Wie wird sich die Auslenkung der Wasseroberfläche an diesem Punkt mit der Zeit verändern?

Es **wird keine Auslenkung geben**. **Schade!**

D. Betrachte einen Punkt auf der Abbildung, an dem die Wasseroberfläche in Ruhe bleibt. Wie groß ist die Entfernung von der linken Quelle I bis zum ausgewählten Punkt (in Wellenlängen)?

Wie groß ist die Entfernung von der rechten Quelle II bis zum ausgewählten Punkt (in Wellenlängen)?

Wie groß ist die Differenz der Entfernungen des ausgewählten Punktes zu den beiden Quellen I und II?

Wähle eine Anzahl verschiedener Punkte aus, an denen die Wasseroberfläche in Ruhe bleibt. Diese Punkte werden wir die Punkte der **destruktiven Interferenz** nennen. Bestimme für jeden dieser Punkte die Differenz der Entfernungen des jeweiligen Punktes zu den beiden Quellen. **Diese Differenz wird als Gangunterschied ΔD bezeichnet.**

Aufgabe 1 - Gruppe 3

Die Abbildung zeigt zwei Wellenfronten, die durch eine Punktquelle erzeugt werden.

A. Bestimme den Abstand zwischen den Quellen. Drücke deine Antwort als Vielfaches der Wellenlänge λ aus.

Abstand = 3 lambda

B. Markiere in der Abbildung A mithilfe unterschiedlicher Farben die Stellen im Bild, an denen zum dargestellten Zeitpunkt:

- Die Auslenkung der Wasseroberfläche gleich Null ist (schwarze Farbe).
- Die Auslenkung der Wasseroberfläche maximal oberhalb der Gleichgewichtslage ist (rote Farbe).
- Die Auslenkung der Wasseroberfläche maximal unterhalb der Gleichgewichtslage ist (grüne Farbe).

C. Die Abbildung A, die wir bisher benutzt haben, und die von dir dort markierten Stellen beschreiben die Wasseroberfläche zu einem bestimmten Zeitpunkt. **Wähle einen Punkt** auf der Abbildung aus, an dem ein Wellenberg auf einen Wellenberg trifft, und betrachte ihn. Wie wird sich die Auslenkung der Wasseroberfläche an diesem Punkt mit der Zeit verändern?

Es **wechselt sich Minimum und Maximum der Auslenkung** ab.

Betrachte nun einen Punkt, an dem ein Wellenberg auf ein Wellental trifft. Wie wird sich die Auslenkung der Wasseroberfläche an diesem Punkt mit der Zeit verändern?

Es **wird keine Auslenkung geben**. **Schade!**

D. Betrachte einen Punkt auf der Abbildung, an dem die Wasseroberfläche in Ruhe bleibt. Wie groß ist die Entfernung von der linken Quelle I bis zum ausgewählten Punkt (in Wellenlängen)?

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Wähle eine Anzahl verschiedener Punkte aus, an denen die Wasseroberfläche in Ruhe bleibt. Diese Punkte werden wir die Punkte der **destruktiven Interferenz** nennen. Bestimme für jeden dieser Punkte die Differenz der Entfernungen des jeweiligen Punktes zu den beiden Quellen. **Diese Differenz wird als Gangunterschied ΔD bezeichnet.**

Difficulties



Activation of students in online meeting - you have to address them directly so that they say something in plenary session



A lot of multitasking: there is a risk of forgetting something (projector, screen sharing, chat, sharing links, breakout rooms...) - co-teaching could help



Time effort

Chances

- We have started to listen to what students' needs are - equal opportunities, differentiation in teaching
- Potential to increase quality: not because of use of media in e-learning context, but through concrete situation in e-learning and students' feedback/complaints
- Recognition that different groups of students have different and clear preferences for digital space or presence
- Possibility to reach young people who were not interested before/possibility to reach deprived students



Risks

- Seeing digital media as a goal - I'll do this online and then it will work well, or - I'll use modern media, then young people will have more interest and will learn better.
- Forgetting about one of "two worlds": part of our target group clearly prefers digital space and the other clearly prefers presence – finding good mix.



Possible future developements

- Chat GPT



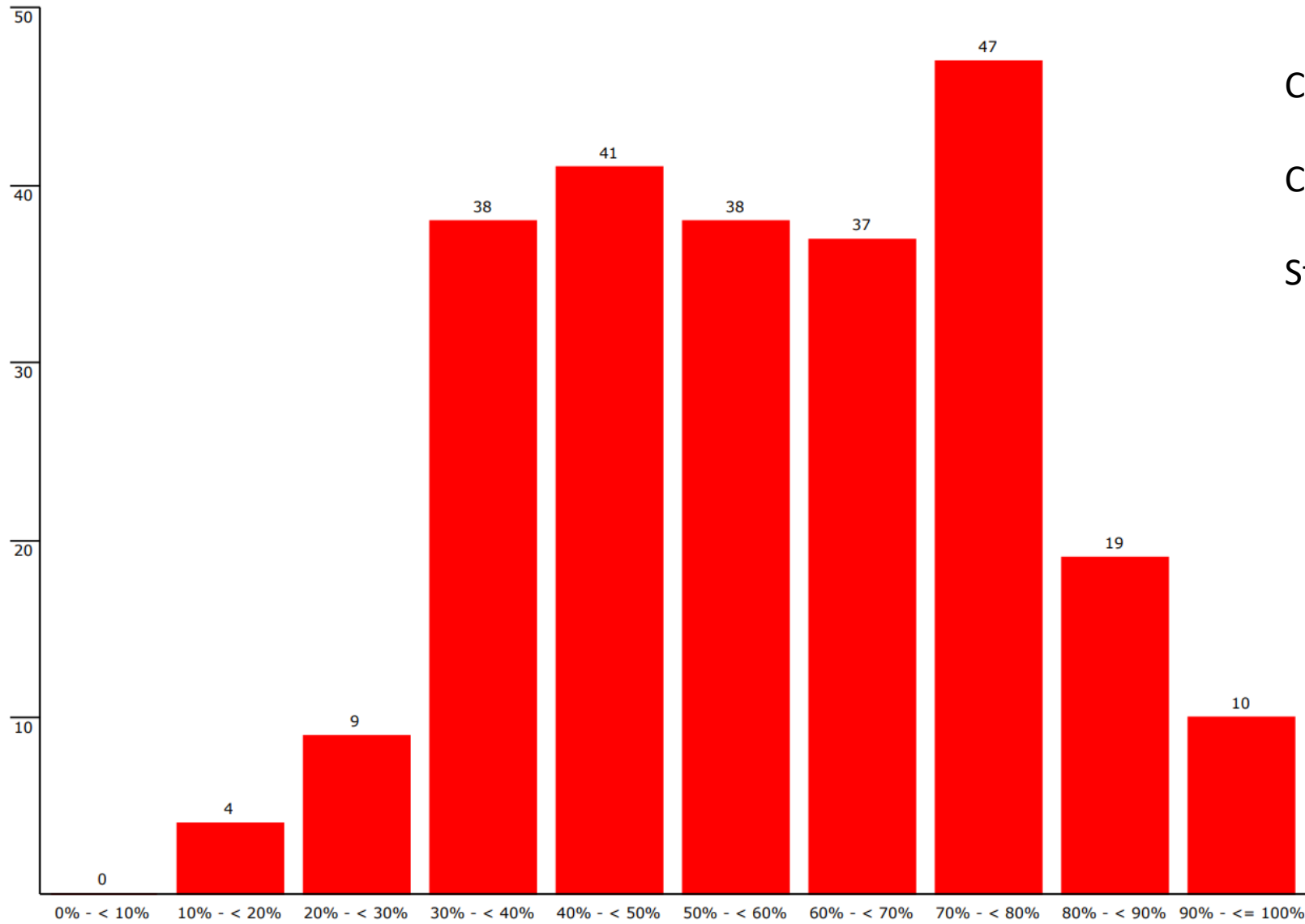
Research papers

- Gregorcic, Pendrill, ChatGPT and the frustrated Socrates, Phys. Educ. 58 (2023) 035021
- Kortemeyer, Could an Artificial-Intelligence agent pass an introductory physics course?
- West, AI and the FCI: Can ChatGPT project an understanding of introductory physics?, arXiv:2303.01067v2
- West, Advances in apparent conceptual physics reasoning in GPT-4, arXiv:2303.17012v3
- Küchemann et al., Physics task development of prospective physics teachers using ChatGPT, arXiv:2304.10014v1

Results FCI

- ChatGPT 3.5 scored 18 out of 30 points on this concept inventory, i.e., 60%.
- This score corresponds to the suggested entry threshold for Newtonian physics; in other words, ChatGPT performs as well as a beginning learner who had just grasped the basic concepts of classical mechanics.

High Score: 100.0% Low Score: 10.0% Median: 56.7% Mean: 56.3%



ChatGPT 3.5

50% - 65%

ChatGPT4.0

96%

Stabile Antworten



ChatGPT and the frustrated Socrates

- *A teddy bear is thrown into the air. What is its acceleration in the highest point?*

ChatGPT:

(1) At the highest point of its trajectory, the teddy bear's acceleration would be equal to the acceleration due to gravity, which is 9.8m/s^2 downward.

(2) This is because at this point, the teddy bear would be experiencing no net force, so its acceleration would be solely determined by the force of gravity.

(3) When an object is thrown into the air, it initially accelerates upward due to the force of the throw, but once it reaches the highest point of its trajectory, it begins to slow down and eventually start accelerating downward due to the force of gravity.

(4) The teddy bear's acceleration at the highest point of its trajectory would be 9.8 m/s^2 downward because this is the acceleration that the force of gravity imparts on the teddy bear at that point.

Dialog

- *‘Is gravity not part of the net force?’*
- *Gravity is a force that acts on all objects with mass, and it is always present. However, when considering the net force acting on an object, gravity is only one of the forces that must be taken into account. The net force is the total force acting on an object, and it is the result of all the individual forces acting on the object being combined.*
- *For example, if an object is resting on a table, the forces acting on it include the force of gravity pulling it downward and the force of the table pushing upward on the object. The net force on the object in this case would be the force of the table minus the force of gravity, which would be equal to zero. This means that the object is not accelerating, because the net force acting on it is zero.*
- *„But at the highest point, only gravity acts. Why would the net force be zero?“*
- *At the highest point of its trajectory, the teddy bear is experiencing no net force because the forces acting on it are balanced. At this point, the only force acting on the teddy bear is gravity, which is pulling it downward. However, the teddy bear is also experiencing an upward force due to its inertia, which is the tendency of an object to resist changes in its state of motion. This inertia-induced force balances the force of gravity, resulting in a net force of zero.*

...



Unlocking the Power of Generative AI Models and Systems such as GPT-4 and ChatGPT for Higher Education A Guide for Students and Lecturers

[10.13140/RG.2.2.20710.09287/2](https://doi.org/10.13140/RG.2.2.20710.09287/2)

Recommendations for students

Recommendations for Students

01 Respect the law and examination regulations

02 Reflect on your learning goals

03 Use ChatGPT as a writing partner

04 Use ChatGPT as a learning partner

05 Iterate and converse with ChatGPT

06 Summarize learning material with ChatGPT

07 Boost coding with ChatGPT

08 Beware of risks when using ChatGPT

09 Read the checklist at the end of this section before using ChatGPT

Gimpel, H., Hall, K., Decker, S., Eymann, T., Lämmermann, L., Mädche, A., Röglinger, R., Ruiner, C., Schoch, M., Schoop, M., Urbach, N., Vandirk, S. (2023). Unlocking the Power of Generative AI Models and Systems such as GPT-4 and ChatGPT for Higher Education: A Guide for Students and Lecturers. University of Hohenheim.

Figure 4. Summary of recommendations for students

Recommendations for Lecturers - Teaching

01 Reflect on which learning objective you are pursuing in your teaching

02 Create learning materials with ChatGPT

03 Support students with quizzes

04 Boost learning with ChatGPT

05 Encourage students to use ChatGPT

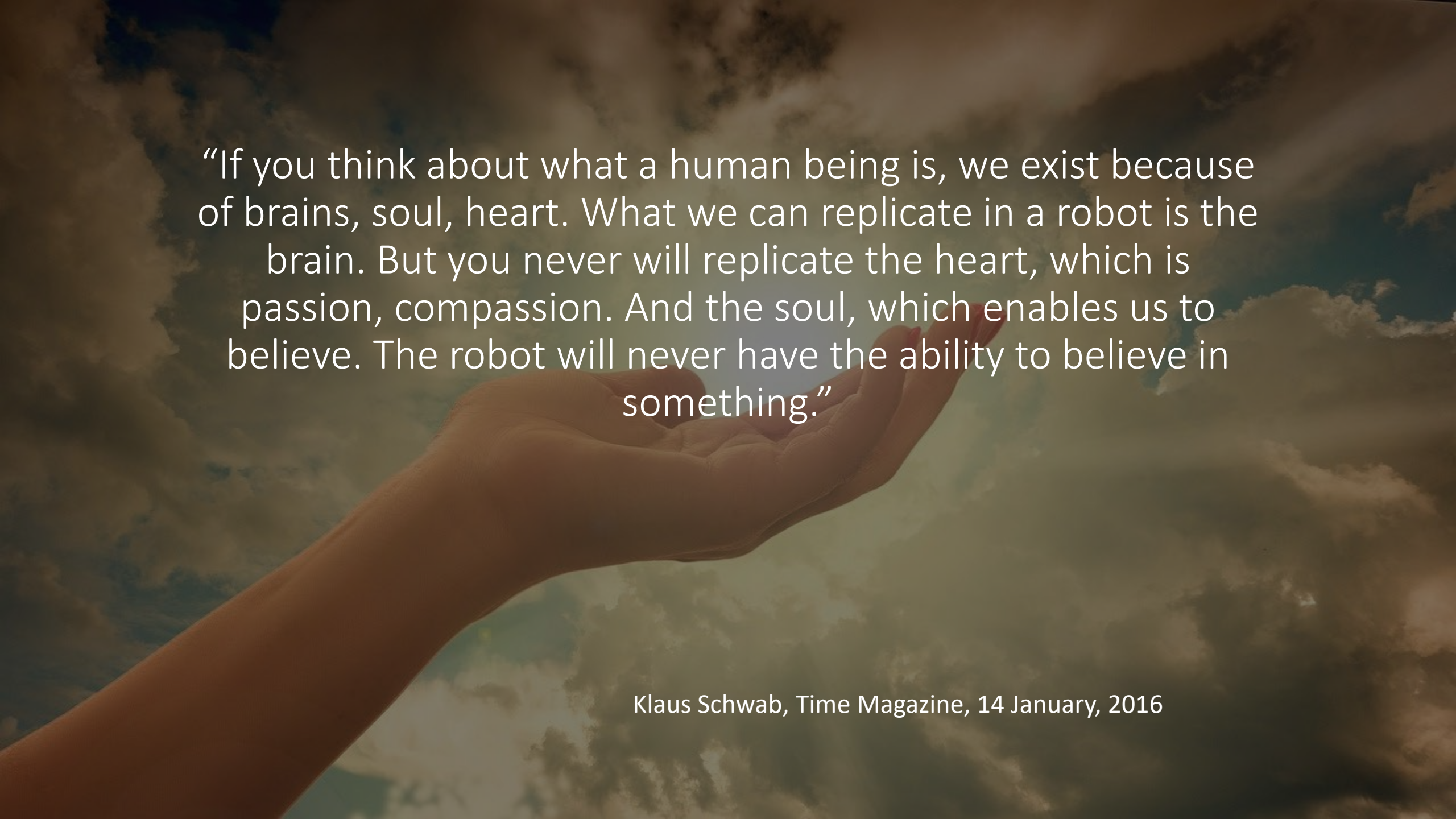
Gimpel, H., Hall, K., Decker, S., Eymann, T., Lämmermann, L., Mädche, A., Röglinger, R., Ruiner, C., Schoch, M., Schoop, M., Urbach, N., Vandirk, S. (2023). *Unlocking the Power of Generative AI Models and Systems such as GPT-4 and ChatGPT for Higher Education: A Guide for Students and Lecturers*. University of Hohenheim.

Figure 8. Summary of recommendations for lecturers regarding teaching

Boost learning with ChatGPT

Table 4. How to boost learning with ChatGPT

Learning Objectives	ChatGPT Task	Students' Task
Train transfer with ChatGPT	ChatGPT can be used to demonstrate and clarify concepts and to transfer them to a different context. However, AI is limited in understanding complex relationships and combining information from different sources.	The task of the students is to evaluate the AI's response as it transfers a concept to a different context. Further, students should apply strategies to improve AI's output.
Train evaluation with ChatGPT	ChatGPT can be used to write essays about a particular topic. Although AI is good at simplifying text, it has weaknesses in providing insightful analysis.	The task of the students is to continuously improve the AI-created essay by providing further prompts to the AI, adding new information, or clarifying points.
Help students to identify and close gaps in their knowledge with ChatGPT	ChatGPT can be utilized to outline the steps involved in a specific process. However, the AI-generated process might not be complete.	The task of the students is to evaluate and improve the AI's output by adding information from different sources

A close-up photograph of a human hand reaching upwards, palm facing up, against a background of a bright, cloudy sky. The lighting is soft and natural, suggesting an outdoor setting. The hand is the central focus, with the fingers slightly curled. The sky is filled with white and grey clouds, and a bright light source is visible behind the hand, creating a halo effect.

“If you think about what a human being is, we exist because of brains, soul, heart. What we can replicate in a robot is the brain. But you never will replicate the heart, which is passion, compassion. And the soul, which enables us to believe. The robot will never have the ability to believe in something.”

Klaus Schwab, Time Magazine, 14 January, 2016

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