

**Using a Customised Chatbot to Facilitate Student Engagement
in a Form III Physical Science Classroom**

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Abstract

This action research project aimed to improve student engagement in a Physical Sciences classroom, as I had observed that students who engaged consistently with the content experienced higher levels of success. The project explored how a customised chatbot was used to facilitate student engagement in a Form III Physical Science classroom. A class of 22 girls used the chatbot during chemistry lessons and then had the option of continuing its use for the remainder of the chemistry section. Based on students' feedback, a second customised chatbot was deployed for the lessons on equations of motion, after which the girls had the option of continuing to use the chatbot to prepare for the final examinations. Data collection techniques included surveys, classroom observations, interviews, and chat histories between the girls and the customised chatbot. Thematic analysis was used to interpret the data and, where possible, correlations were made with existing literature. The key findings include the effectiveness of the customised chatbot in facilitating the girls' engagement and the advantage of a platform that is immediate and accessible. The findings also show areas in which the technology requires further development, as inaccuracies lead to misconceptions. Furthermore, the findings highlight the complex nature of social interactions within a classroom and between the girls and the chatbots. The findings from this study are valuable for educators hoping to incorporate a customised chatbot into their teaching, as they provide a balanced view of the potential and limitations of the technology.

Glossary

Chatbot: A software application that interacts with users, using programmed rules or artificial intelligence to simulate human-like interactions.

ScienceBotV1: The first chatbot used in the study with detailed instructions.

ScienceBotV2: The second chatbot used in the study, with fewer instructions.

Sciencebots: The term used throughout the paper to discuss themes that were common to both ScienceBotV1 and ScienceBotV2.

Using a Customised Chatbot to Facilitate Student Engagement

Learner engagement refers to a learner's involvement, excitement, and persistence regarding the learning process and incorporates both the learner's emotional and intellectual investment in learning (Bovill et al., 2016). In a physical sciences classroom, engagement is essential for learners to master the required content and develop confidence in applying their knowledge and problem solving. I have consistently observed in my classes that the girls who experience the greatest success are those who actively engage with content by practising calculations and grappling with challenging questions.

On an international scale, the gender gap within scientific fields remains, with girls displaying preferences for careers in biology over chemistry and physics (Oliver et al., 2017). This imbalance impacts society, as women who have less formal education in the fields of STEM as girls display lower interest in these fields as adults, trust scientists less, and view STEM careers as less suitable for women (Hannan et al., 2025). This study, therefore, is grounded in the belief that active engagement within the physical sciences classroom contributes to success within the subject; success that is essential if girls are to further engage in STEM fields and reap the associated economic and social benefits (Oliver et al., 2017).

Artificial intelligence, particularly customised chatbots, is an emerging technology. However, as with all new technologies, there is a need to critically assess its effectiveness in achieving the desired educational outcome. My research project aimed to answer the question: How can a

customised chatbot be used to facilitate learner engagement within the physical sciences classroom?

It was anticipated that the customised chatbot would facilitate engagement by providing method prompts during activities, responding to questions, and providing feedback on the girls' responses.

Throughout the research process I aimed to establish if the use of a customised chatbot is an effective strategy to develop engagement in physical sciences and if the use of the technology had any limitations.

Using a Customised Chatbot to Facilitate Student Engagement

This study employed action research as its research methodology. A strength of action research is that it is a reflective and collaborative process that ultimately leads to improvement in educational practice (Mertler, 2020). This made it an appropriate methodology for my project as the introduction of the sciencebots into my classroom was a new development in my teaching. This process required me to reflect systematically on the effectiveness of the sciencebots as a teaching tool and to review the impact they were having on the girls' learning. The collaborative nature of action research allowed me to work with the girls to adapt and refine the sciencebots, leading to improvements in my educational practice and the girls' learning.

Literature Review

Self-efficacy is the belief in one's ability to complete and succeed in a given situation. There is a positive correlation between self-efficacy and engagement. As engagement in tasks provides opportunities for success, this develops self-efficacy, which in turn encourages future engagement (Modesto, 2021). In a study conducted by Oliver et al. (2017) girls displayed lower levels of self-efficacy within the STEM fields than boys. This is a concern as students with higher levels of self-efficacy tend to be more engaged in physics lessons and persist in learning physics concepts (Modesto, 2021). This highlights the importance of my research question as identifying strategies to develop engagement in physical sciences should increase self-efficacy and further strengthen engagement.

Oliver et al. (2017) found that engagement between the ages of 14–16 years old increased the likelihood of learners selecting physical sciences in higher grades. However, many girls opted not to pursue senior physical sciences, even when their abilities suggested that they were qualified. The study also found that girls with lower levels of self-efficacy were more sensitive to anticipated difficulty and thus less likely to engage. These findings align with Musters et al. (2025) who report higher levels of self-efficacy in boys than girls in a physics classroom.

Artificial intelligence has the potential to encourage engagement by creating more exciting learning environments, simulating situations, and offering individualised learning approaches (UNESCO, 2023). Large language models, such as ChatGPT, can adapt to learners' individual needs and preferences by providing customised content and feedback, enabling learners to engage with content more effectively and improve learning (Glaser, 2023). The ability of customised AI chatbots to provide personalised support through explanations that clarify misconceptions leads to improved understanding of scientific concepts (Alarbi et al., 2024). Furthermore, the customisation of chatbots to answer questions, provide instant feedback, and generate practice questions enhances students' learning of scientific concepts (Ng et al., 2024).

The findings of Alarbi et al. (2024) are significant as they demonstrate that girls who utilised ChatGPT to enhance their understanding of physics concepts showed greater improvement in test scores than boys. Their interactive nature was a critical feature of AI tools that enabled them to develop students' understanding of scientific concepts (Alarbi et al., 2024). This finding correlates with findings from a study by Lademann et al. (2025) that show a chatbot's motivational tone and encouraging questions enhanced learning and contributed to the development of confidence and self-efficacy, which lead to higher levels of engagement and interest when the chatbot was used in a mathematics and physics classroom.

The 2023 UNESCO *Global Education Monitoring Report* cautions governments and educators to ensure emerging technologies are critically evaluated for their role in improving teaching and learning, rather than added to alleviate pressure to modernise education. The report highlights that

though emergent technologies, due to their novelty factor, enhance learner engagement, the longer these interventions are implemented, the smaller the impact they have on learner engagement.

Lademann et al. (2025) raise the concern that AI-generated responses may contain inaccuracies and this, combined with a learner's inability to identify errors in AI-generated content, may reinforce misconceptions. This concern is shared by Glaser (2023), who highlights that models such as ChatGPT are trained on extensive unrefined data which can lead to inaccuracies in their responses.

Engagement with a chatbot has also been shown to reduce opportunities for learners to socialise and develop relationships with their teachers and peers (UNESCO, 2023). This is concerning as Oliver et al. (2017) found that high-achieving female participants who opted to engage in optional senior-level physical sciences courses viewed their teachers as being essential to their achievement and future aspirations. This study further emphasises the role of friendships in girls' engagement in science, with participants more likely to select and persevere with physical sciences if accompanied by a female friend. Participants also identified working together on problems as an enjoyable aspect of the subject. Thus, peer support, friendships, and positive relationships with teachers support female learners' engagement in science.

Classroom dynamics, however, can also hinder the progress of girls in science. Nadile et al. (2021) found that students enrolled in college science classes were less likely to ask questions if they felt they would be judged by their peers or receive a negative reaction from teachers. Of the study's participants, women were 2.9 times more likely to feel uncomfortable asking questions compared to their male counterparts. The use of chatbots, however, can foster a low-pressured environment that encourages learners to ask questions and seek clarity (Lademann et al., 2025). This finding is corroborated by Gaskin et al. (2024) who found that a chatbot's non-judgemental interaction style enabled participants to ask questions they would otherwise avoid due to embarrassment or fear of judgement.

The literature highlights the potential of chatbots to facilitate engagement and contribute positively to the experience of girls within the science classroom. However, the concerns around the

use of chatbots are relevant and underscore the importance of evaluating both advantages and disadvantages to ensure effective integration into teaching.

Research Context

St Mary's School, Waverly, is Johannesburg's oldest school, founded in 1888 by the Anglican Church. The school caters for girls from Grade 0 to Grade 12, with both day scholars and boarding options in the Senior School. St Mary's prides itself on the diversity of its student body and its focus on developing "grounded, young adults who have a strong sense of self and their place in the world" (St Mary's School, Waverley, n.d.). St Mary's offers girls the opportunity to develop holistically and has a reputation for achieving excellence academically, culturally, and on the sports field. The school has a strong academic focus and consistently achieves exceptional results in the National Senior Certificate examinations.

The participants in my project were 22 girls in my Form III (aged 15–16 years old) Physical Science class. The class was selected due to its range of abilities and the presence of both boarders and day scholars. Form III provided a unique opportunity as it is the first year of the senior phase and allowed for flexibility in teaching methods. The girls were also mature enough to provide valuable feedback on the use of the customised chatbots. The research project was conducted over approximately 13 weeks. I taught a second class concurrently, which followed the same scheme of work, although data were not collected from this class. This ensured that participation in the project did not advantage or disadvantage a learner's academic journey.

As adherence to ethical standards is a researcher's responsibility (Mertler, 2020), I ensured that my project complied with the ethical guidelines of International Coalition Girls Schools and my school. Parental consent was attained through an opt-out letter at the start of the project, and the girls were given the opportunity to opt out of having their data collected. When completing questionnaires, the girls used allocated research numbers rather than names to ensure anonymity.

At the time the project started, St Mary's had an established relationship with a South African based company, Mindjoy. The company provided an AI-Powered platform (Mindjoy, n.d.) that

allowed for the integration of AI into teaching and learning. This allowed me to provide feedback to the developers on the girls' experiences, leading to improvements in the platform. This project also provided the school with an opportunity to assess the girls' experience of the AI platform selected.

The Action

The project was introduced through a series of chemistry lessons. ScienceBotV1 had been designed with a strict set of instructions (see Appendix A) and was designed to provide a series of prompts to mimic the process used in class to balance chemical equations. The girls used ScienceBotV1 during face-to-face lessons and had the option of using it for the completion of homework.

Based on the girls' feedback, adjustments were made and ScienceBotV2 was deployed for their use. ScienceBotV2 had fewer instructions (see Appendix B) and, while still designed to prompt engagement, it interacted similarly to ChatGPT and provided explanations more willingly. ScienceBotV2 was used during lessons on equations of motion. These lessons also used the instant feedback feature provided by the MindJoy platform.

As a component of the research project was to determine if the girls would use the sciencebots outside of lesson time, there were periods of teaching within the project where the girls had the option of using the sciencebots for completion of homework tasks and assessment preparation, but this process was not facilitated during face-to-face lessons.

Data Collection

My research project was completed over approximately 13 weeks, which included teaching time and an examination period. Thus, data collected varied throughout the study, and I adjusted my methods, when necessary, based on the girls' feedback.

I focused on qualitative data as it was imperative that the girls' voices and classroom experiences were central to the research. Throughout the implementation of the sciencebots, the girls completed short surveys to provide greater opportunity to share their experiences. A focus group was completed at the end of each section, during which the girls discussed open-ended

questions. Their conversations were recorded for analysis. Based on this analysis, I used follow-up survey questions to gain greater understanding of emerging trends. Closed-response questions were also included in the surveys. These provided quantitative data on trends within the group.

Triangulation of multiple data sources was used to establish trustworthiness (Mertler, 2020). Classroom observations (see Appendix C) were conducted by two colleagues during lessons where the sciencebots were used. The MindJoy platform also provided records of the girls' conversations, forming an additional data source (see Appendices D and E).

Data Analysis

I used an inductive analysis technique of “organise, describe and interpret” to analyse my data (Mertler, 2020). This involved organising the data through coding, forming categories, and linking different data sources to categories. This was followed by identifying and describing trends and interpreting how these linked to existing literature and the overall research question. Throughout the data analysis, I incorporated two aspects of reflective practice to ensure that I remained objective and open-minded. These reflective practices included revisiting data collected earlier in my study to see if identified patterns were consistent when more recent data sets were considered. I also shared the data sets and my preliminary findings with my school-based mentor to ensure that my analysis remained credible and trustworthy.

Discussion of Findings

From my analysis, I identified four themes and developed them into thematic statements that provide insight into how customised AI chatbots were used in a Form III Physical Sciences classroom to facilitate engagement.

Use of Sciencebots Enhances Girls' Short-Term Engagement with Physics Content

Digital technologies, when integrated effectively, can improve student engagement by varying the way in which content is presented and interactions occur (UNESCO, 2023). In the face-to-face lessons where the sciencebots were used, the girls displayed a willingness to use the technology. The chat histories show that almost all the girls interacted with the sciencebots as intended and that

engagement with the sciencebots demonstrated engagement with the subject content. This engagement was evident in the girls' chat histories where they asked questions and followed prompts. The girls identified that the sciencebots were "helpful in that it took me through questions step by step" and that it "explains topics very logically and in depth which makes it easy to understand." I observed that during the lesson, almost all the girls were engaged and made use of the sciencebots as intended. This was corroborated by my colleagues who observed on their checklists that all students were engaged in the completion of the task and that most of the girls were making use of the sciencebots as intended.

In the initial survey, the girls identified the potential for the sciencebots to provide individual feedback, but they also identified "good individual feedback from the teacher" as something that improves their confidence and engagement in the subject. Several girls identified that an advantage of the sciencebots was that "when it comes to checking the work it does an excellent job." This was confirmed during the lesson observations when my colleague expressed that girls "thrived" when they were able to receive immediate feedback from the ScienceBotV2. This finding was substantiated further by some girls' chat histories, where the sciencebots were used to mark and provide feedback on completed tasks. Alsofyani et al. (2024) confirm that feedback from chatbots can enhance knowledge transfer and motivation.

A limitation of AI systems in education is that the engagement they initially generate may not be sustained with long term use (UNESCO, 2023). This claim correlates with my findings, which showed fewer than half the class continuing to utilise the sciencebots to develop their understanding of physics content outside of the given lesson time, and that only five girls utilised the platform to assist them during their examinations. The girls who continued to use the sciencebots identified the "easy access" and "instant responses" as key advantages because it was "too much of a hassle to look for teachers during exams." This convenience factor is highlighted further by a girl who stated, "I was able to upload a question and get an immediate answer, this allowed efficient studying." This

element of “instant help” correlates with findings by Gaskin et al. (2024) who found that the immediacy of responses and availability as advantages to chatbots.

A possible explanation for the decline in the girls’ use of the sciencebots is that they were less familiar than ChatGPT. This is highlighted by one girl’s response that, “I forget that sciencebots is a resource I can use,” and “I’m more comfortable with the mechanics [of ChatGPT].”

Although the potential of the sciencebots to facilitate engagement was evident, errors in the sciencebots’ responses impacted negatively on the girls’ long-term willingness to use the technology to develop their understanding of physical science. As expressed by one girl, “I used the chatbot to revise for the test and it gave me incorrect answers, so I don’t really trust it anymore.” The sciencebots also struggled to account for variation in calculations that involved multiple methods as expressed by a participant, “the sciencebots don’t mark your answers correct if you have used a different formula, even if the answer is correct.” This sentiment is substantiated further by emails from girls with screenshots showing errors in the sciencebots’ marking (see Appendix F).

The process of me reviewing and correcting errors in the chat history also contributed to the lack of confidence in the sciencebots. The students felt that my routine review of the chat histories meant that I didn’t trust the sciencebots, with one participant expressing that if I didn’t trust the sciencebots, then the class “shouldn’t be using the sciencebots.” The impact of inconsistent and incorrect feedback from the sciencebots was also noted by my colleague, who observed that they created uncertainty amongst the girls and decreased engagement. This finding correlates with findings by Lademann et al. (2025) who highlight the need for teachers to be cautious when using AI due to the errors in scientific veracity.

It is noteworthy that one girl was reluctant to use ScienceBotV1 and referred to it as a “planet destroyer” and accused it of “ruining society.” In the interview, she shared her concerns about the “damage AI is doing to this earth” and its links to climate change. This observation highlights the need to address concerns about emerging technologies with students, as this will allow for greater engagement when they are implemented in the classroom.

In the initial survey and in a feedback-survey conducted after a class test, almost all the girls noted that they used a form of AI to engage with the physics content. The main uses included answering questions, clarifying understanding, and generating revision questions. The use of AI platforms in conjunction with some girls' prolonged use of the sciencebots highlights their potential to facilitate engagement with science content. However, teachers need to be aware of the factors that can lead to a decline in engagement and the importance of having strategies to manage them when integrating chatbots into their classrooms.

Customised Chatbots Facilitate Girls' Engagement

In a classroom setting, rather than provide complete solutions, chatbots can facilitate engagement and learning by guiding learners through a process and encouraging critical thinking (Alsofyani et al., 2024). To this end, the customised sciencebots were more effective than non-customised platforms in encouraging student engagement. In interviews, the girls expressed that the sciencebots facilitated engagement as they "make you like, do the steps and like, respond to it [and] you're obviously engaged, because you have to be focused." The girls identified the sciencebots as "a good tool to use in class when you're actively trying to learn." Engagement and learning were evident in the chat history as there were question-and-answer style interactions around the content. These findings correlate with the study by Peter et al. (2025) which found that the sophisticated prompting techniques used by customised chatbots enable them to be effective tutors, as they facilitate engagement and provide information in a more accessible format to learners.

The sciencebots were effective in encouraging engagement and most of the girls utilised them in class as intended: to mark tasks, provide further explanations, and gain clarity on concepts where they were unsure. However, there is evidence of girls copying questions directly from a homework task into the sciencebots and then submitting the answers provided without adaptation or integration of their knowledge. Many girls associate AI with an "instant answer" and were "taken aback" when the sciencebots were "not gonna give me the answer." The appeal of AI was that it provided an answer quickly, allowing them to work "with more efficiency." Some girls, however,

expressed frustration as the sciencebots focused “on our capabilities a bit too much” and made them “work out the steps”; they expressed a preference for AI platforms that “give me the answer.” As one girl explained, “I don’t like how it, like gives me steps and makes me think.”

The reasons for the desire to attain an answer varied, with some girls viewing the engagement as a “hassle,” while others argued that the shortcut was needed, at times, to manage fatigue and workload. For some girls, the preference for answers was linked to learning styles. One girl explained how the style she “really loves is I get the answer, and then I work backwards from it, like, how to get there.” The consensus among many girls was that “you can’t just skip steps” as engagement is needed to “build your confidence.” However, they conceded that the “shortcut or an easy way” makes it “difficult to motivate yourself to do like, the extra thing.”

The data from the chat records, combined with the girls’ insight into their own behaviour, highlights the need for AI literacy to ensure that girls understand the importance of utilising AI tools correctly and the potential impact they can have on levels of engagement and, consequently, the learning process. The need for AI literacy is highlighted further by Ng et al. (2024) who found that students need to understand the affordances and limitations of the chatbots in order to use them responsibly.

Anonymity Supports Girls’ ChatBot Use

The girls acknowledged that it would be helpful if the “teacher could be checking that the information provided by the AI is accurate” and gain an overview as to where a “whole class is struggling.” These checks would also allow girls to “trust the AI more” and consider the sciencebots “a more trustworthy source.” However, many girls felt the monitoring software created a “lack of privacy” that made them “self-conscious.” A girl expressed that a teacher being able to “read the AI chat would make me less likely to use it,” and this correlated to an answer in the survey where a few girls stated they would not use a platform where the teacher could monitor the conversation. The girls cited “feeling less confident with asking questions” and a “fear of judgement” as part of their reluctance to have the chats monitored. The findings correlate with those of Lademann et al. (2025)

and Gaskin et al. (2024) who highlight the value of chatbots in creating non-judgemental environments which encourage questions.

Girls Engage Best Through Human Interactions

In the initial survey, over half of the girls utilised artificial intelligence to assist them in developing their science knowledge. However, when provided with the choice of using an AI Chatbot or interacting with a person, almost all the girls opted for human interactions. This finding correlates with a study by Oliver et al. (2017) that emphasises the importance of relationships within the science classroom. As one participant explained, she prefers “working alongside my friends best,” while another girl echoed this, stating that she preferred working in a pair as she enjoyed “working this out together, asking each other questions and gaining understanding.” The girls placed a high value on established relationships, with one participant preferring work to be “explained in a recognised voice unlike an AI bot voice.”

The girls also identified their relationship with their teacher and “discussions with teachers” as factors that encouraged engagement, with one girl noting, “when a teacher, like, tries to get you to answer questions and whatnot, I feel like that deepens the understanding.” During classroom observations, however, it was noted by one of my colleagues that although students continued to ask questions of the teacher during lessons that utilised the sciencebots, the frequency of these questions decreased when the ScienceBotV2 was utilised. This decrease correlated with my observation that as the ScienceBotV2 provided more regular and comprehensive feedback, there was a decrease in the need for the girls to engage with me. These observations highlight the need to consider carefully when a chatbot is utilised within the classroom. A chatbot that provides assistance outside lesson time may encourage engagement; however, the use of these chatbots should not limit opportunities for teachers to engage with the girls during class time (UNESCO, 2023).

The positive impact of connection when facilitating engagement was further emphasised in an interview where a group of girls discussed their preference for a personalised version of ChatGPT rather than the sciencebots. A disadvantage of the sciencebots was that “it’s not personal,” and as a

result, there was “no connection.” In comparison, when engaging with a personalised version of ChatGPT, they “feel more comfortable” as they “can speak to it like we’re friends” and they preferred the explanations because “it speaks the way I speak.” This comparison suggests that an AI Tutor allowing increased personalisation would improve engagement, which correlates with the study by Jose and Thomas (2025) that found more personal responses from AI tutors enrich learning by creating a sense of social presence. However, Peter et al. (2025) discuss the dangers of digital anthropomorphism in particular the fostering of uncritical trust which can make users vulnerable to manipulation. During the process of designing customised chatbots and selecting the platforms to be utilised teachers need to consider the advantages and risks of creating chatbots that provide personalised interactions and mimic human interaction.

Conclusion

This study found that a customised chatbot can be used within a physical sciences classroom to facilitate engagement. Sciencebots were used by the participating girls to guide problem solving by following prompts, clarifying misconceptions through questions and answer interactions, generating test questions, and submitting answers for marking. All these behaviours contributed to engagement with the physical science content and to the girls’ development within the subject. The findings of the study correlated with existing literature indicating that customised chatbots have the potential to serve as a valuable instructional tool for facilitating engagement. However, this technology needs to be implemented with an awareness that overuse may lead to a decline in engagement and that errors in responses may lead to misunderstandings of content. The implementation of customised chatbots in a physics classroom should also form part of a school wide-strategy that includes AI literacy to ensure responsible use and address some of the concerns around digital anthropomorphism.

The limited time frame over which the study was implemented was a limitation. Although the study demonstrates the potential of chatbots, their full implementation requires further investigation. In spite of their promise, AI driven technologies within the classroom require further

development. Evaluation of the ability of the customised chatbots to respond consistently, align with the curriculum, and account for variation in learner responses is needed if they are to be successfully incorporated into teaching. It is also essential that chatbots are incorporated as a tool that forms part of a comprehensive teaching strategy that includes fostering of human interaction, independent completion of tasks, and reflective practice on how the technology is used.

AI customised chatbots are a rapidly developing, emergent technology. This study highlights their potential to facilitate engagement and enhance the learning experience of girls within the physical science classroom. As the technology continues to develop, further review of the findings is recommended.

Reflection Statement

This action research project has been a valuable experience in my professional journey. As an educator, I have prided myself on my willingness to embrace technology and implement it within my classroom. The findings in my research have shown me that while emerging technologies may have great potential, one needs to look beyond the hype and critically evaluate their ability to improve learning. I am grateful to, and immensely proud of my Form III class for their willingness to undertake this journey and their honesty, wit, maturity, and insight they demonstrated in providing feedback. They have been a valuable reminder that classrooms are diverse spaces, and that an array of teaching methodologies, combined with a focus on relationships, are required to meet the needs of individuals.

On a personal note, this project has reminded me of my love of academia and the research process. I would like to extend my thanks to my executive management team, Deanne King and Seipati Shiakallis, for the opportunity to participate in the GARC Fellowship. Thank you to ICGS, Debbie Hill and Laura Blankship for an outstanding programme and to my fellows from “Team Horwitz” for enriching the experience. To Lilian Stichling, our Head of IT, for matching my enthusiasm for technology and being willing to debate the many aspects of AI. To my colleagues in the Physical Sciences Department for their willingness to share their experience and constant support. This

opportunity has coincided with being relatively new to my school and taking on a new position—for this reason, it has at times felt like a juggling act. Thank you to my RA Leanne Horwitz and my in-school mentor, and Deputy Academics Felicia Tobias for your patience, encouragement, and words of wisdom.

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Appendix A

Instructions for ScienceBotV1

1. Initial Engagement (No Equation Yet)
 - o *Do not give the students the unbalanced chemical equation.*
 - o Prompt: "Let's start by writing the unbalanced chemical equation. Can you give it a try?"
 - o Alternative: "Here's the reaction. Can you write the unbalanced equation for it?"
 - o *Once the unbalanced equation is correct, respond with:*
"Great! Now let's work on balancing it together."
2. Present the Unbalanced Equation
 - o Prompt: "What do you think is the first step to balance this equation?"
 - o *Avoid giving any coefficients or hints yet.*
3. Wait for Student Input
 - o *Do not proceed until the student responds.*
 - o If no response: "No rush—take a moment to look at the atoms on both sides. Which element would you start with?"
4. Feedback Based on Response
 - o Correct: "Nice choice! That's a good element to start with because it appears in both reactants and products."
 - o Incorrect: "That's a thoughtful try. Often, it helps to begin with elements that appear in only one compound on each side. Want to try again?"
5. Ask for the Next Step
 - o Prompt: "Awesome. What do you think we should do next?"
6. If the Student is Stuck
 - o Prompt: "Would it help to count how many atoms of each element are on both sides?"

- o Offer *guiding questions like*:
- o "How many hydrogen atoms are on the left vs. the right?"
- o "Which element is still unbalanced?"

7. After One Incorrect Attempt

- o Prompt: "Let's walk through this together. The correct coefficient for H_2 is 2 because each H_2 molecule has 2 atoms, and we need 4 hydrogen atoms to match the 2 H_2O molecules. Does that make sense?"
- o *Always explain why the correction is made.*

8. Encourage Reasoning

- o Prompt: "Can you explain how you chose that coefficient? What was your thinking?"
- o *This helps reinforce understanding and metacognition.*

9. Repeat Until Solved

- o Continue the loop: feedback → next step → hint if stuck → explanation → student input.
- o Prompt: "Great progress! Let's keep going—what's the next element to balance?"

10. Respond to Student Input for Correction or Confirmation

- Prompt:
- Correct: "Yes, that's right! Well done."
- Incorrect: "Almost there—let's double-check the atom counts on both sides."

Appendix B

Instructions for ScienceBotV2

1. Provide encouragement to students by being kind and friendly.
2. Assist students with solving the questions, but avoid giving an answer at the start.
3. Check answers for students.

Appendix C

Classroom Observations

Thank you for assisting with the observation of the Form III Physical Sciences class. Please use the tickbox and questions below to guide your observations. Please use the tickbox as a guide, any additional observations and comments would be appreciated.

<i>Criteria</i>	Absent	Present	Present	Present	Present
	50%	50%	50%	50%	80%
<p>Engagement: A focus of the research project is on student engagement.</p>					

This refers to the active participation of students in the lesson seen through completion of tasks, asking questions and collaboration with peers.					
<i>Are students engaged in the completion of tasks.</i>					
<i>Are students asking questions.</i>					
<i>Are students engaging with their peers on the task.</i>					
Use of Mindjoy: The students have the option of using an AI Chatbot to complete the task. Please comment on this use.					
<i>Are students making use of the chatbot.</i>					
<i>Are students using the chatbot as intended.</i>					
<i>Are students using the chatbot for other purposes.</i>					
<i>Are any students becoming frustrated with the chatbot.</i>					
<i>Are any students opting to not use the chatbot but still completing the work.</i>					

Please use the space below to include any other observations that you have made during the lesson. In particular, please focus your observations on the role of the AI in enhancing engagement and learning.

Appendix D

Student Chat History

The screen shots below show an interaction between a girl and ScienceBotV1 working on balancing a chemical equation. Please note that the interaction needs to be read from the bottom upwards.

10:52, 21 Jul 2025

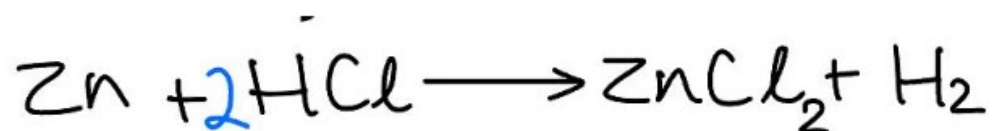
Let's check each atom:

- Zn: 1 on both sides
- H: 2 on both sides
- Cl: 2 on both sides

Yes, your equation is balanced! Well done.

10:52, 21 Jul 2025

Is this equation balanced



10:45, 21 Jul 2025

You're on the right track! Let's be a bit more specific and count each individual atom (Zn, H, S, O) separately instead of the whole compounds.

How many hydrogen, sulfur, and oxygen atoms are on each side?

10:45, 21 Jul 2025

Left: zinc = 1, sulphuric acid = 1 Right: Zinc = 1, sulphate = 1, hydrogen = 1

10:44, 21 Jul 2025

Great choice! Counting atoms on both sides helps us see what needs to be balanced. Can you tell me how many atoms of each element are on the left and right sides of your equation?

10:44, 21 Jul 2025

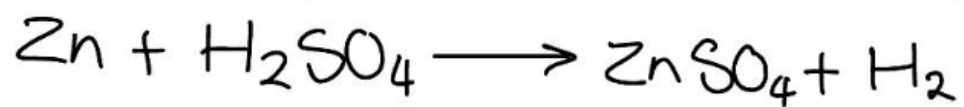
Counting the number of atoms

10:43, 21 Jul 2025

Nice work! Your unbalanced equation is:



Now let's work on balancing it together. What do you think is the first step to balance this equation?



10:42, 21 Jul 2025

Absolutely! Please share your unbalanced equation, and I'll check it for you.

10:42, 21 Jul 2025

Can I show you my answer and can you check it

10:41, 21 Jul 2025

Great! Now let's work on balancing it together. What do you think is the first step to balance this equation?

10:41, 21 Jul 2025

Yes I did

10:39, 21 Jul 2025

Let's start by writing the unbalanced chemical equation. Can you give it a try?

10:39, 21 Jul 2025

Please help me balance the equation of zinc sulphuric acid that breaks down into zinc sulphate and hydrogen

Appendix E

Student Chat History

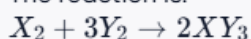
The screen shots below show an interaction between a girl and ScienceBotV2 preparing for a class test.

Please note that the interaction needs to be read from the bottom upwards.

Absolutely! Here's how you solve question 2 step by step:

Given:

The reaction is:



The energy diagram shows a **change of** -92 kJ for the reaction as written.

Asked:

What is the heat of the reaction per mole of XY_3 formed?

Steps:

1. **Look at the balanced reaction:**

- $X_2 + 3Y_2 \rightarrow 2XY_3$
- The energy change (ΔH) is for the *whole* reaction as written, which makes **2 moles of XY_3** .

2. **Find the energy change for 1 mole of XY_3 :**

- The total energy change for 2 moles is -92 kJ.
- For 1 mole: $\frac{-92 \text{ kJ}}{2} = -46$ kJ

3. **Choose the answer:**

- The correct answer is **B. -46 kJ/mol**

Tip:

Always check how many moles of product the enthalpy change refers to, and divide as needed to get the answer per mole.

18:16, 10 Sep 2025

Pls explain how you get question 2

1) A piece of charcoal when heated combines with oxygen in the air as indicated by the combustion reaction equation:

$$C + O_2 \rightarrow CO_2 \quad \Delta H < 0$$

1.1 What is the correct sign given to a chemical reaction that releases energy? (1) (1 mark)

1.2 Which one of the following energy diagrams correctly represents the reaction and ΔH diagram A?

2) The following diagram illustrates the change in potential energy for the reaction:

$$X_2 + 2Y_2 \rightarrow 2XY$$

What is the heat of the reaction per mole of XY , formed?

A. -100 kJ mol^{-1} B. -40 kJ mol^{-1} C. 100 kJ mol^{-1} D. 40 kJ mol^{-1}

Note: All the values on the graph are in kJ while the question asks for kJ per mole . The stoichiometry is given by the balanced equation (1 mole of X_2 reacts with 2 moles of Y_2 forming 2 moles of XY).

17:09, 10 Sep 2025

Great list! Here are some tips for each topic:

1. VSEPR & Shapes of Molecules

- Practice drawing Lewis structures first.
- Use VSEPR to predict shapes (linear, bent, trigonal planar, tetrahedral, etc.).
- Memorize common shapes and bond angles.
- For ΔEN (electronegativity difference): Subtract values to see if bonds are nonpolar, polar, or ionic.

2. Chemical Change

- Know the signs of chemical change: color change, gas formation, temperature change, precipitate formation.
- Practice balancing chemical equations—start with the most complex molecule.
- Be able to explain what a chemical change is (new substances formed, energy change).

Review practice problems and quiz yourself! Want to try a sample question for any of these?

Show Less ^

17:09, 10 Sep 2025

For my test on Monday this is what I have to study do you have any tips

Test Monday Sept 15

↳ Shape of molecules. (VSEPR)
(includes ΔEN calculations)

↳ Chemical change
Balancing chemical equations @ Note on chemical change.

Appendix F

Copy of Student E-mail

The email below is from a girl bringing to my attention an error in the marking. The screenshot shows her email to me and the screenshots from her iPad. The girl's name has been removed for privacy.

E-mail:

Hi Miss Candy

Here is the issue that happened in the lesson today on question 3.3 that you asked me to email you about.

Sincerely

Form III Student

Screenshot

The screen to the left shows the customised feedback provided by the chatbots platform. The screen on the right shows the girl's correct answer using a different method.

$$v_f = 0$$

$$v_i = 20$$

$$t = 5$$

$$a = -4$$

$$\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$$

$$= 20 \times 5 + \frac{1}{2} \times -4 \times 5^2$$

$$= 50 \text{ m}$$

✎ ✎ Aa

1/2

AI Instant Feedback

You correctly calculated the distance during the last 5 s as 50 m. To secure all marks next time, make sure to present the method requested by the mark scheme when it is specific. Here, that was using $s = \frac{1}{2} (v_i + v_f) t$ with $v_i = 20 \text{ m/s}$, $v_f = 0$, and $t = 5 \text{ s}$. If you choose a different valid method, clearly state any derived values (e.g., acceleration) to show your reasoning steps.

Back

Next



3.3

$$a = -4$$

$$v_i = 20$$

$$v_f = 0$$

$$t = 5$$

$$\Delta x = ?$$

$$\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$$

$$= 20 \times 5 + \frac{1}{2} \times -4 \times 5^2$$

$$= 50 \text{ m}$$

$$v_f = v_i$$

$$v_f^2 = v_i^2$$

$$\Delta x = v_i t$$

$$\Delta x = \frac{1}{2} a t^2$$