Overall grade: A

Performance Standards for Stage 2 Scientific Studies

	Investigation, Analysis, and Evaluation	Knowledge and Application
A	Critically deconstructs a problem and designs a logical, coherent, and detailed scientific investigation using a scientific method and/or engineering design process. Obtains, records, and represents data, using appropriate procedures, conventions and formats accurately and highly effectively. Systematically analyses and interprets data and evidence to formulate logical conclusions with detailed justification. Critically and logically evaluates procedures and their effect on data. Critically and perceptively evaluates the effectiveness of collaboration and its impact on results/outcomes.	Demonstrates deep and broad knowledge and understanding of a range of science inquiry skills and scientific concepts. Applies science inquiry skills and scientific concepts highly effectively in new and familiar contexts. Critically explores and understands in depth the interaction between science and society. Communicates knowledge and understanding of science concepts coherently, with highly effective use of appropriate terms, conventions, and representations.
B	Logically deconstructs a problem and designs a well-considered and clear scientific investigation using a scientific method and/or engineering design process. Obtains, records, and represents data, using appropriate procedures, conventions and formats mostly accurately and effectively. Logically analyses and interprets data and evidence to formulate suitable conclusions with reasonable justification. Logically evaluates procedures and their effect on data. Critically evaluates the effectiveness of collaboration and its impact on results/outcomes.	Demonstrates some depth and breadth of knowledge and understanding of a range of science inquiry skills and scientific concepts. Applies science inquiry skills and scientific concepts mostly effectively in new and familiar contexts. Logically explores and understands in some depth the interaction between science and society. Communicates knowledge and understanding of science concepts with mostly coherent and effective use of appropriate terms, conventions, and representations.
C	Deconstructs a problem and designs a considered and generally clear scientific investigation using a scientific method and/or engineering design process. Obtains, records, and represents data, using generally appropriate procedures, conventions and formats with some errors but generally accurately and effectively. Undertakes some analysis and interpretation of data and evidence to formulate generally appropriate conclusions with some justification. Evaluates procedures and some of their effect on data. Evaluates the effectiveness of collaboration and its impact on results/outcomes.	Demonstrates knowledge and understanding of a general range of science inquiry skills and scientific concepts. Applies science inquiry skills and scientific concepts generally effectively in new or familiar contexts. Explores and understands aspects of the interaction between science and society. Communicates knowledge and understanding of science concepts with generally effective use of appropriate terms, conventions, and representations.
D	Prepares a basic deconstruction of a problem and an outline of a scientific investigation using a scientific method and/or engineering design process. Obtains, records, and represents data, using procedures, conventions, and formats inconsistently, with occasional accuracy and effectiveness. Describes data and undertakes some basic interpretation to formulate a basic conclusion. Attempts to evaluate procedures or suggest an effect on data. Attempts to evaluate the effectiveness of collaboration and its impact on results/outcomes.	Demonstrates some basic knowledge and partial understanding of science inquiry skills and scientific concepts. Applies some science inquiry skills and scientific concepts in familiar contexts. Partially explores and recognises aspects of the interaction between science and society. Communicates basic scientific information, using some appropriate terms, conventions, and/or representations.
E	Attempts a simple deconstruction of a problem and a procedure for a scientific investigation using a scientific method and/or engineering design process. Attempts to use some procedures and record and represent some data, with limited accuracy or effectiveness. Attempts to describe results and/or interpret data to formulate a basic conclusion. Acknowledges that procedures affect data. Acknowledges the effectiveness of collaboration and its impact on results/outcomes.	Demonstrates limited recognition and awareness of science inquiry skills and/or scientific concepts. Attempts to apply science inquiry skills and/or scientific concepts in familiar contexts. Attempts to explore and identify an aspect of the interaction between science and society. Attempts to communicate information about science.

Please note:

- **This is one task from a folio comprising five tasks and may not be representative of the overall Folio grade.**
- **Any notes in coloured text boxes are added to provide information and support for teachers.**
- **Parts of the student report have been highlighted with the colour that corresponds to the colour of the relevant text box.**

Introduction

The quantity of diabetic Australians is highly prevalent with numbers rising daily (Diabetes Australia, 2015) (figure 1). The current accumulation of diabetic patients has prompted new insulin related treatments to be developed which assists type one diabetics as well as insulin-reliant type two diabetics. The Science as a Human Endeavour concept discussed will be development, specifically the development of new technologies that improve the efficiency and convenience of monitoring blood glucose levels and administration of insulin in diabetics. The development of insulin pumps such as the, Omnipod Dash (Insulet), may revolutionise the treatment of insulin-reliant diabetes, therefore replacing or modifying previous treatments.

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Source: Data extracted by AIHW (January 2013) from the Department of Human Services website

Prescriptions claimed for diabetes medicines, 1992–2012

Figure 1- Increase of diabetic Australians, accessed from the Department of Human Services (January 2013) accessed, 26/04/19. https://www.pdhpe.net/health-

KA3 SHE key concept has been identified as the focus of the task

Science background

With reference to figure 2, Diabetes is the term given to a collection of different conditions in which the body cannot maintain healthy levels of glucose in the blood. People suffering from the most common variations of diabetes are referred to as, type two and type one diabetics. Type two diabetes is a condition where the blood glucose level increases to an unhealthy concerntration (American Diabetes Association, n.d.). Type 2 diabetes develops when the body becomes resistant to insulin or when the pancreas is unable to produce enough insulin. The exact cause is unknown, although genetics and environmental factors, such as being overweight and inactive, are believed to be contributing factors (Mayo clinic, n.d.). To compensate, the body will produce a greater amount of insulin, but eventually the homeostasis concerntration will not be fulfilled and an external source of insulin will be required. Homeostasis concentration relates to the bodies desired blood glucose levels. Human body's homeostasis concentration is between 70 mg/dl and 110 mg/dl (James Norman MD, FACS, FACE, 2016). Below 70 mg/dl is termed "hypoglycaemia." Above 110 can be normal if the patient has eaten in the last 2-3 hours. Above 180 mg/dl is termed "hyperglycemia".

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Figure 2- Effects of type one diabetes in comparison to non-diabetics. Joshua Abbas, n.d., accessed 5/4/2019 (https://www.123rf.com/photo_32265676_stock-vector-type-1-diabetes.html

Type 1 diabetes is a condition in which causes are unknown, although several risk factors have been identified. The risk of developing type 1 diabetes is increased by certain variants of the HLA-DQA1, HLA-DQB1, and HLA-DRB1 genes. These genes provide instructions for constructing proteins that play a critical role in the immune system. If a parent carries these genes it is believed by many diabetes researchers including Janelle A. Noble, that the child is more likely to develop this variant of diabetes in their adolescence (National Library of Medicine, 2019). Type 1 diabetes is an auto-immune condition in which the immune system forms a misguided attack destroying the cells in the pancreas, known as beta cells, which produce insulin (Diabetes Australia, 2015). Insulin is a hormone produced in beta cells and responds to irregular blood glucose levels. The beta cells responsible for creating insulin, are located in the islets of Langerhans alongside, alpha and delta cell. Collectively these cells produce glucagon, insulin and somatostatin. These hormones regulate one another's secretion through paracrine cell interactions as they have inverse reactions (Adam Augustyn, n.d.). When glucose is gained from consumption of carbohydrates, protein or lipids, the blood glucose levels increase and insulin is secreted from the pancreas to regulate the blood glucose levels by transporting the excess glucose into muscle or liver cells, there for restoring it back to homeostasis concentration (RMIT University, 2015). Insulin reliant diabetes, if left untreated, will result in a reduction of glucose in muscle and liver cells thus resulting in the body sourcing lipids to burn as a form of energy, opposed to aerobic respiration. Diabetic Ketoacidosis occurs as the burning of lipids produces ketone chemicals due to the breakdown of fatty-acids and glycerol, therefore resulting in the acidity of the blood increasing. Low blood Ph. (metabolic acidosis) is an undesired condition as it would affect the functions of enzymes due to their requirement of 7.0pH to 7.4pH to operate effectively (BBC, n.d.). This would furthermore hinder metabolic processes as enzymes play a crucial role in breaking down large molecules. Both variants of diabetes have the possibility to be fatal if left untreated, yet there are treatment methods such as insulin pumps that, if completed properly, will keep the person suffering at a healthy blood sugar level.

KA1 Student shows a knowledge and understanding of a range of relevant scientific concepts.

KA4 These have been communicated coherently.

SHE aspect- development

The development of type one diabetes is not caused from lifestyle choices, therefore it is not a reversible condition. Thus, various developments of treatments to manage the condition have been made. In January 1922, the first ever injection of insulin into a patient occurred, prior to this, those diagnosed with diabetes survived approximately weeks to a month (Diabetes UK, 2017). The 14 year old injected with insulin from a dog, regained strength and the mass production of insulin began (Forester McClatchy, 2016). The treatment of diabetes was temporary, therefore patients requiring insulin would require regular follow up injections. This process, although beneficial, was highly inconvenient as insulin lasts in the body for a maximum of 8 hours, therefore injections were made persistently. This posed difficulty as the treatment would affect schooling and work lives. Originating in 1963, the first insulin pump was prototyped by Dr Arnold Kadish, in order to inject insulin conveniently without a doctor (Diabetes UK, n.d.). As seen in figure 3, this pump was very large and impractical, but it regulated blood glucose levels and injected insulin every 5 minutes, revolutionising the treatment of diabetes. After the initial insulin treatment in 1922, various developments of alternative treatments were made. Appendix A shows the development of earlier models of insulin delivery highlighting their flaws and the need for further development.

Image removed due to copyright

Figure 3- First insulin pump

Kingsley Ibietela, January 24, 2016, Assessed 5/04/2019 https://healthable.org/the-evolution-

KA3 Illustrates how scientific knowledge has links with the development of technology to assist with insulin management in diabetes

In 2018 a company named Omnipod engineered a tubeless, waterproof, Bluetooth, touchscreen system that provides up to 72 hours of non-stop insulin, accompanied by a device similar to a smart phone which regulates the blood sugar levels (Omnipod, 2019). Omnipod DASH system is the only wearable, tubeless, closed-loop insulin delivery product, currently available for investigative use and can be worn anywhere an injection would be administered. As seen in figure 4, the cannula inserts automatically with the push of a button therefore allowing for a simple transmission and once the period of insulin release is completed, the pod can easily be refilled (Omnipod, 2019). The feature of a monitoring device allows the patient to adjust and manage insulin doses through Bluetooth, and review and share information with family, friends or doctors accordingly (Omnipod, 2019). Additionally, depending on insurance companies, Omnipod systems may be purchased utilizing Pharmacy Benefit, therefore reducing the economic concerns associated with diabetes. Evidently, the development of insulin pumps has effectively improved the efficiency of insulin transmission. From a large impractical backpack, to a small tubeless Bluetooth pod these devices have not only become more accurate in blood glucose regulation, but has also allowed for discretion of treatment. The new technologies also have the capability to monitor blood glucose levels on various devices allowing families peace of mind.

Image removed due to copyright

Figure 4- Administration of Omnipod

Omnipod, 2019, accessed 8/04/2019 https://www.myomnipod.com/DASH

Future impacts

KA3 Shows how scientific and technological advances interacts with society.

The Omnipod dash system has various features that are highly beneficial for society, primarily the Bluetooth component allowing family and medical professionals to monitor the sufferer's blood glucose levels and insulin transmission. Due to 60% of type 1 diabetics being under the age of 25, this feature is highly beneficial as children's treatment can be easily monitored by parents and medical professionals, to insure the optimal treatment (Australian Government, 2018). New technologies such as Omnipod dash, are evidence of the improvements made to previous systems in order to improve experience of treatment. This is completed by improving the materialistic properties,

efficiency of transmission and the accuracy of blood glucose analysis. An experiment conducted by Trang T. Ly, MBBS, PhD, Senior Author, Paediatric Endocrinologist and Medical Director at Insulet Corporation, studied the efficiency of Omnipod dash over standard insulin treatments. The 12 day study conducted was carried out with adults who had established type 1 diabetes. The aim was to demonstrate the safety and efficacy of the system in a real-life setting. Eleven adults, ages 28.8 +/- 7.9 years, whose average disease duration was 14.9 years, with a haemoglobin A1c (HbA1c) of 7.4 +/- 1.2% were enrolled. In the first phase, all participants followed a seven-day phase-in protocol using standard therapy (either an insulin pump or multiple daily injections) with an additional pump at home. The second phase lasting five days, consisted of participants consuming unrestricted meals and wearing the Omnipod dash system. It was discovered that the time-in-range (at the homeostatic blood glucose level), improved by an average of 11.2% when utilizing the Omnipod dash program in comparison to standard therapy, (73.7%, versus 62.5% respectively) (Endocrine web, 2018). This study demonstrations the efficiency and accuracy of this development, as it results in an increased time-in-range. In addition, the participants using the Omnipod system experienced reduced hypoglycaemia, which together with the findings demonstrates the performance and safety of the Omnipod system while supporting greater freedom in patient's daily activities due to the mobility of the product (Endocrine web, 2018). Dr. Ly expressed that "The research we are presenting at ADA is from our five-day study of adults, but it was also studied in adolescences, and children ages 6 years and older with equally promising results," (Endocrine web, 2018). This therefore displays that for a predominantly adolescence disease, with the benefits of Bluetooth compatibility, parental or personal monitoring and improved time-in-range, the Omnipod system is a highly beneficial development of insulin treatment. With the knowledge of the Omnipod pumps efficiency, future technologies can be developed, acting on this systems benefits and flaws, to produce better systems. A few possible improvements for future technologies include, greater time-in-range, less refills, environmentally aware (recyclable disposables or constructed out of recycled materials) and economic adjustments.

Possible limitations facing the Omnipod system involves, cost of treatment and availability. Those who have difficulties financially may have trouble affording the treatment as it is ongoing, therefore constant payments are necessary. There is an opportunity for the systems cost to be covered by insurance, however those who don't have enough money to buy it outright, will most probably not be able to afford insurance either. Another limitation includes accessibility, as of now Omnipod is only available in USA but in the future will be available in other 'first world' countries but will not be available in more remote countries (Omnipod, 2019). This means, those with type 1 or insulin reliant type 2 diabetes in a countries where this treatment has not been cleared for use, will be unable to utilize the revolutionary technology.

KA1 Demonstrates an awareness and understanding of scientific inquiry processes in research that drives future scientific developments

KA3 Awareness of the potential benefits of further applications of technology on improved health and wellbeing of individuals

KA3 Limitations to the technology is discussed and how this might impact individuals

Conclusion

The continuous developments of diabetes treatment, in particular insulin injections, has provided promising new developments that greatly improve the treatment of insulin reliant diabetes. With sources completing trials and research, the benefits of the newest developments in comparison to older treatments could be perceived. The development of the newest insulin pumps has a clear purpose to improve the process of insulin delivery by producing unique features that benefit society as the accuracy of treatment, as well as the motorization and comfort is improved. The development of the Omnipod system is important as it improved the monitoring and efficiency of treatment, thus benefitting patients who need supervision or assistance in completing their treatment. The proven efficiency of this development allows future developers to utilize the knowledge of this system and act upon its flaws to develop a more advance treatment that will benefit all insulin reliant diabetics.

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KA4 Report was supported by a number of in-text references from a range of researched sources which have been displayed conventionally