

# INTRAVENOUS CANNULATION SIMULATOR FOR HEALTH EDUCATION

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## Abstrak

Kompetensi pemberian terapi intravena sangat diperlukan bagi tenaga kesehatan, sebab terapi intravena merupakan prosedur invasif yang paling sering dilakukan. Terapi intravena bertujuan untuk memberikan cairan kepada pasien, ketika pasien tidak dapat menelan, tidak sadar, dehidrasi atau syok untuk mempertahankan keseimbangan elektrolit atau glukosa yang diperlukan untuk metabolisme dan memberikan medikasi. Kegagalan dalam insersi vena akan menyebabkan tromboflebitis dan trauma pada pasien. Penggunaan alat peraga menjadi media pendukung untuk mencapai kompetensi siswa yang diharapkan. Intravenous Cannulation Simulator yang dilengkapi dengan flow sensor didesain menyerupai lengan dan kecepatan aliran darah artifisial menyerupai manusia. Peraga berupa simulator ini bertujuan membantu peserta didik melakukan kanulasi intravena dengan kompeten, sehingga dapat meminimalisir kesalahan di lahan praktik. Hasil uji statistik dengan Wilcoxon signed rank test menunjukkan ada pengaruh penggunaan Intravenous Cannulation Simulator terhadap nilai praktikum pemasangan infus. Uji efektifitas Intravenous Cannulation Simulator dilakukan melalui angket tertutup menggunakan skala likert. Hasil yang diperoleh adalah praktikan menyatakan simulator intravenous cannulation efektif digunakan sebagai alat peraga praktikum pemasangan infus, pengambilan sampel darah dan pemberian terapi intravena. intravenous cannulation simulator mampu meningkatkan minat, keterampilan berfikir, dan keinginan belajar lebih lanjut peserta didik.

**Kata Kunci:** Simulator; Intravenous Cannulation; Skala laboratorium

## Abstract

*The competence of providing intravenous therapy is very necessary for health workers, because intravenous therapy is the most often performed invasive procedure. Intravenous therapy aims to deliver fluids to the patient, when the patient is unable to swallow, unconscious, dehydrated or in shock to maintain the balance of electrolytes or glycosis necessary for metabolism and administer medication. Failure in venous insertion will cause thrombophlebitis and trauma in the patient. The use of teaching aids is a supporting medium to achieve the expected competencies of students. The Intravenous Cannulation Simulator equipped with a flow sensor is designed to resemble an arm and an artificial blood flow speed resembles a human. This simulator aims to help students competently perform intravenous cannulation, so that they can minimize errors in the practice field. The results of the statistical test with the Wilcoxon signed rank test showed that there was an effect of the use of the Intravenous Cannulation Simulator on the value of the IV installation practicum. The effectiveness test of the Intravenous Cannulation Simulator was carried out through a closed questionnaire using a likert scale. The results obtained were that the practitioner stated that the intravenous cannulation simulator was effectively used as a practical prop for infusion installation, blood sampling and intravenous therapy. Intravenous Cannulation Simulator is able to increase students' interest, thinking skills, and desire to learn further.*

**Keyword:** Simulator; intravenous cannulation; Laboratory scale

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## INTRODUCTION

Intravenous therapy is treatment by inserting solutions, medications, blood or blood products directly into a vein. Intravenous therapy is an effective and fast way to administer fluids or medications in emergency situations for patients who are unable to take medications orally. About 80% of all patients in the hospital receive intravenous therapy (Perry, Potter, & Ostendorf, 2025).

Giving fluids through an infusion is the act of inserting fluids through intravenously into the patient with the help of an infusion device. These actions are carried out to meet the needs of fluids and electrolytes as well as as a treatment and feeding action. Intravenous (IV) Therapy (intravenous cannulation) is an action aimed at providing fluids to the patient, when the patient is unable to swallow, unconscious, dehydrated or in shock to maintain the balance of electrolytes or glucoses necessary for metabolism and administering medication. Failure in venous insertion in the administration of therapy, will lead to thrombophlebitis and trauma in the patient (Adi, Giri et al., 2022). Intravenous therapy is an effective and efficient method to supply the body's fluid and electrolyte needs (Ariningrum & Subandono, 2018). Types of intravenous therapy include IV push/bolus (giving medicine from a syringe directly into the blood vessel using a syringe slowly), intermittent infusion (a small amount of medicine is inserted into the vein through the intravenous fluid in a certain amount of time), continuous infusion (inserting a large amount of intravenous fluid or medication dissolved in the intravenous fluid and administered by continuous drops) (Zakaria & Askaria, 2020). The place or location of the peripheral veins that are often used on the infusion installation is the supervisial or peripheral cutaneous vein located in the subcutaneous fascia and is the easiest access to intravenous therapy (Adi, Giri et al., 2022).

Intravenous fluid administration is the most common invasive procedure practiced in hospitals. Globally about 25 million people receive intravenous fluid therapy. Improper administration of intravenous fluids can affect the patient's condition, increase morbidity and even mortality. Healthcare providers in developing countries have skills gaps related to intravenous fluid administration. Nurses and midwives who performed inadequate IV practice were 2.1 times more likely to have nurses and midwives with less knowledge compared to those with adequate knowledge (Teshome et al., 2023). Infusion therapy can carry the risk of infection that causes microbes to enter the bloodstream that has the potential to cause phlebitis. The three main factors that cause phlebitis are chemical, mechanical or technical and bacterial. Efforts to prevent phlebitis are required by nurses to comply with the installation of infusions in accordance with operational standards. The incidence of phlebitis is due to the lack of nurse knowledge and skills in the installation of the infusion. The incidence of phlebitis in Indonesia carried out at Bunda Prabumulih Hospital is 8% to 17% and at Karawang General Hospital. With the causative factors The use of "Human Patient Simulation Manikins" can increase knowledge and critical thinking skills, as well as increase student satisfaction with practicum learning. Patient simulation mannequins are widely used in health professional education, because they can teach psychomotor skills, and high student satisfaction with the use of simulations (Lapkin et al., 2010). The effective and efficient use of pre-practice media is needed in practicum learning to avoid damage and material losses (Botturi, 2019). Simulation applications as a pre-practice learning medium can provide the right output results, can better understand the material given, and minimize the occurrence of errors when practicing with real tools (Kashikar et al., 2019).

Practicum of providing intravenous therapy is a basic competency that must be possessed by health students. The props in the IV installation practicum, using a phantom arm which is a manufacturer's product, with silicone leather material connected to several hoses and a pump to drain artificial blood, this system is still manual, so that when the pump does not work, the blood

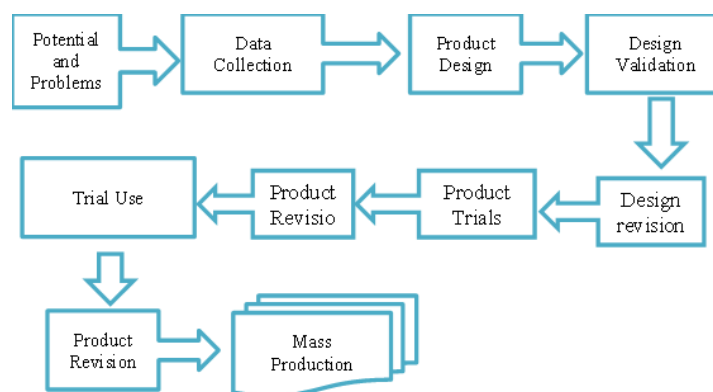
flow cannot flow. The unbalanced ratio of users and the number of mannequins makes phantom easily damaged, where artificial blood flow hoses leak due to repeated use of abocath.

The need for teaching aids innovation that not only has an affordable price but is also able to describe the anatomy of the human arm as closely as possible, and has an automated system so that it makes it easier for students during practicum. The appropriate use of educational technology can support the achievement of various learning domains such as cognitive, affective, and psychomotor. Instructional technology is defined as the study and ethical practice of facilitating learning and improving performance through the creation, use, and management of appropriate technological processes and resources. Instructional technology development involves the process of analyzing, designing, producing, implementing, controlling, and evaluating technology-based learning models (Giovanni & Nurhayat, 2025). The use of modified tools as a simple clinical learning medium resembling tools or mannequins is actually very helpful for students in independent skills. Modified teaching aids are easy to obtain and similar to the original and easy to use and maintain, as well as reduce the unit cost of financing independent skills in the Clinical Skills Laboratory, in addition to the results of modified consumables are also useful in reducing the waste of non-infectious consumables in the Skills Laboratory (Patmawati & Hidayati, 2020).

This research develops intravenous therapy teaching aids designed as teaching aids for midwifery/health students to be skilled and competent not only in the administration of intravenous therapy but also in intravenous injection skills, and blood sampling. The update of this research is Intravenous Cannulation Simulator Designed using peristaltic pump as an artificial blood automatic drive motor, thereby reducing the risk of clogged flow, the use of Flow Sensor which serves as an artificial blood rate speed control made to adjust to blood rate in humans, thus distinguishing it from the manufacturer's phantom (Simeone et al., 2023)

Previous research conducted by (Ningsih, 2021) entitled Design and Build a Flow Rate and Pressure Monitoring System Plant Simulator Flow Control, where this study discusses the flow rate and pressure monitoring system using an Arduino Mega 2560 microcontroller and an effect-based flow sensor Hall. The technologies and methods used in the study can be applied in a medical context to monitor blood flow. The monitoring system designed in the study shows how flow sensors can be used to accurately measure and monitor fluid flow.

This research aims to develop learning media that is able to simulate actual conditions so that it can minimize errors in the practice field. The resulting product is expected to motivate students to be more interested in the infusion installation practicum and improve learning outcomes. The use of motors and flow sensors is a new innovation in health aids that can project or approach the actual state of anatomy.



**Figure 1. Research and Development Steps**

## METHOD

The type of research used is Research and Development which is commonly abbreviated (R&D), with two approaches, namely qualitative and quantitative. The product development procedure in this study refers to the Borg and Gall model modified by (Saputro, 2017), which includes figure 1.

The product development carried out in the research only reached the stage of producing the final product, namely the Intravenous Cannulation Simulator Data collection technique using questionnaires. The questionnaires given are in the form of a questionnaire for validation of material experts, validation of electrical experts and users/students. The questionnaire used is a likert scale questionnaire to collect data on the evaluation of material experts, product experts, and users/students after observing the developed product. The product trial was carried out in a small group of 10 students, and the use test was carried out by 35 students. The questionnaire instrument grid for material experts, product experts and users is shown in the table 1.

**Table 1. The questionnaire instrument grid**

Data Source	Aspects	Indicators	Item Number Question
Material Experts and Users (students)	Relationship with teaching materials	<ul style="list-style-type: none"> <li>• Compatibility with the material concept</li> <li>• Product clarity and actual anatomy</li> <li>• The level of need for tools for learning</li> </ul>	1,2,3
	Educational Value	<ul style="list-style-type: none"> <li>• Compatibility with the intellectual development of students</li> <li>• Improved competencies of students</li> <li>• Conformity with core competencies</li> </ul>	4,5,6
	Effectiveness	<ul style="list-style-type: none"> <li>• Effectively used to explain material</li> </ul>	7
Product experts (electric) and students (users)	Product Design	<ul style="list-style-type: none"> <li>• Describe the anatomy of the human arm</li> <li>• Suitability of the use of materials</li> <li>• Elastic sleeve leather</li> <li>• Artificial veins are easily palpable</li> </ul>	1,2,3,4
	Tool Durability	<ul style="list-style-type: none"> <li>• Tool resistance when cannulated</li> <li>• Easy to maintain</li> <li>• Electrical components are not easily damaged</li> </ul>	5,6,7
	Tool Accuracy	<ul style="list-style-type: none"> <li>• The appliance can function properly when in use</li> <li>• The veins on the arm correspond to the anatomy</li> <li>• Easy to cannulate</li> </ul>	8,9,10
	Effectiveness	<ul style="list-style-type: none"> <li>• Ease of tooling (using and re-storing)</li> <li>• Ease of use</li> <li>• Effectively used to explain material</li> </ul>	11,12,13
	Tool Safety	<ul style="list-style-type: none"> <li>• Safe Tool Construction for Students</li> <li>• Artificial blood uses safe ingredients when exposed to the skin</li> <li>• Comfortable tools to use by students</li> </ul>	14,15,16

The likert scale questionnaire sheet consists of a scale of 5 (Very Good), 4 (Good), 3 (Sufficient), 2 (Less), 1 (Very Poor). The results of the assessment will be used to measure the validity of the product based on the criteria of the percentage assessment of the validation score according to (Saputro, 2017) are as table 2.

**Table 2. Percentage of product validity score assessment**

Yes	Rating level	Valid criteria
1	80,1-100%	Highly valid (No revision required)
2	60,1-80%	Valid (No revision required)
3	40,1-60%	Invalid (revision)
4	20,1-40%	Invalid (revision)
5	0-20%	Very invalid(revision)

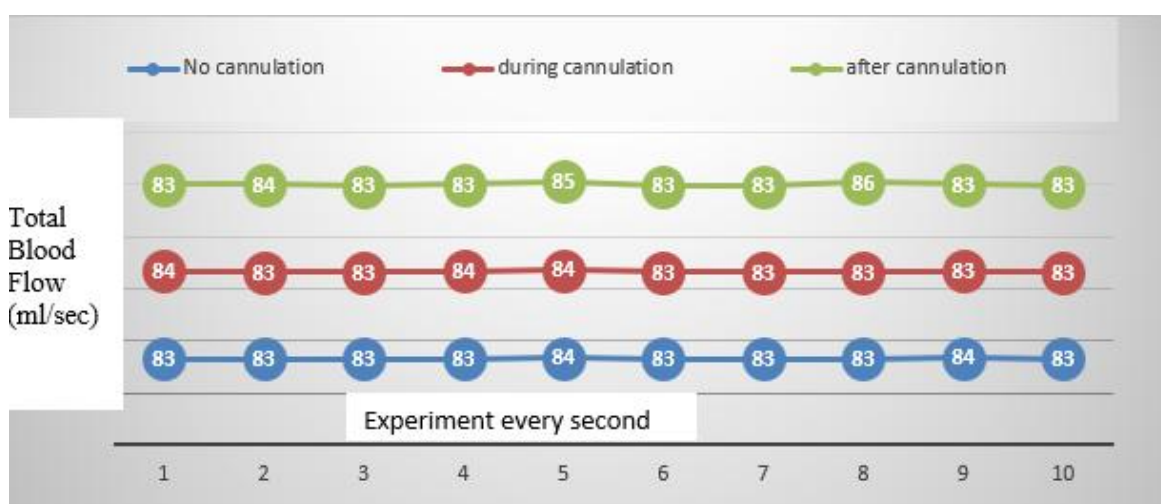
## RESULT

Research starting from the stage of potential analysis and problems is carried out to determine the problems and potentials needed in the development of learning media/teaching aids can be made as close as possible to the situation in the practical field, so that the potential can be used as an advantage to be able to solve existing problems. measuring the need for the importance of props. Observation was carried out regarding the teaching aids used in the IV installation practicum or intravenous therapy in the obstetric laboratory, the mannequins used as props have been mostly damaged, this is due to the frequency of use and the ratio of the instruments are unbalanced, the intravenous therapy teaching arm available in the laboratory cannot give an idea of the blood flow rate. The next stage is to collect data related to solving the problem of lack of ratio of tools to students, as well as the development of props to be able to display venous cannulations realistically. The design of the product is made to resemble an arm equipped with a blood flow rate sensor, with reference to some literacy to simulate a good product. The need for technology development in the world of education is inseparable from teaching materials or learning media, so that learning is more interesting and interactive. Teaching materials play a crucial role in education by supporting systematic learning, fostering student independence, and reducing reliance on teacher (Apriyanti et al., 2025; Muzainuddin et al., 2024).

The manufacture of silicone sleeves used for intravenous cannulation was formulated using research references conducted by (Engers et al., 2020) although it does not accurately mimic the geometry and mechanical properties seen in different groups of patients. Formulation used in the manufacture of sleeves with the composition, silicone rubber (100) : catalyst ( 2 %). After the ingredients are mixed perfectly, they are placed on the mold and waited 24 hours to get maximum results. Phantom silicone with precise formulation and strong elasticity, can be a phantom outer shell replacement spare parts as per practicum requirements (Sari et al., 2025)

The blood flow rate is automatic, starting when the arduino starts running the uploaded code, and all components are ready for initialization where the Arduino Uno initializes every connected component, including the driver motor, YF-S201 flow sensor, and 16x2 I2C LCD. This initialization includes initial configuration, such as setting up communication with the sensor and setting up the LCD display to be ready to display data. Arduino reads data from the YF-S201 flow sensor, which generates a pulse signal whenever a liquid passes through the sensor. This signal represents the speed or volume of blood flow. Based on the number of pulses received from the flow sensor, Arduino calculates the flow rate of blood. Arduino applies a predetermined formula or calibration to convert the number of pulses into a corresponding unit of flow rate, in mL per second. At this stage, the system will check if the blood flow rate is within a predetermined or desired range. If the flow rate is within the appropriate range, the system proceeds to the next stage. If the flow rate is not suitable, then the Arduino will send a signal to the driver motor to adjust the peristaltic pump speed so that the blood flow rate returns to the desired range.

The results of blood flow rate measurements that have been calculated using arduino are displayed on the 16x2 I2C LCD screen. This display allows users to see the value of the blood flow rate in a Real-time. The process is complete after the data is displayed, but usually the system will go back to the previous step and continue to monitor the blood flow rate repeatedly for continuous monitoring. The resulting blood flow rate refers to the normal human blood flow rate of 5 L/minute or 83.3 ml/second. The speed of arterial blood flow ranges from 4.9-19 cm/second, while venous blood flow is much slower, which is 1.5-7.1 cm/second. Taking into account the corresponding vessel diameters ranging from 800 microns to 1.8 mm, the blood flow rate is 3.0-26 ml/min in the arteries and 1.2-4.8 ml/min in the veins or 0.08 ml/sec. The speed of blood flow will vary in each part of the body. In the part of the body where the blood has just been pumped, the flow speed ranges from 30-45 cm/second. This speed fluctuates especially when a person is doing strenuous activities such as exercise (Alodok, 2018). In this study, the blood flow rate was regulated using the formula of  $\text{ml/sec} = (\text{flow\_frequency} \times (1000/450))$  so that a blood flow range of 0-255 ml/sec was produced which could be adjusted using a hose locking ring. The following are the results of the artificial blood flow rate stability test, before cannulation, during cannulation and after cannulation.



**Figure 2. The results of the artificial blood flow rate stability test**

The Intravenous Cannulation Simulator was evaluated for feasibility through a validation test by 1 material expert, 1 electrologist, and 3 students as users. After the product design is validated, it is known that the weaknesses or shortcomings of the product can be corrected so that the product can be valid for practical use. After the product is declared valid, the product is tested in a small group, namely 5 students, the trial is carried out with the aim of whether the teaching aids are more effective, easy to use, safe and comfortable to use so that they can support learning. After the test of the product is successful, then the product is tested for use by a large group of 35 students. The results of the trial are presented in Table 3.

Based on table 3, it is known that the validation results from the subject matter expert mentioned the simulator, effective use, described educational value and in accordance with the teaching material to explain the material of infusion installation and release with an average value of 76%, the validation test from the product expert stated that the simulator had a good level of resistance even though repeated cannulations were carried out, no leaks occurred, the design depicted a human arm, The simulator is safe and easy to use with an average score of 80%.

**Table 3. The results of the trial**

Data Source	Aspects	Result
Material Experts and Users (students)	Relationship with teaching materials	70
	Educational Value	77
	Effectiveness	80
Product experts (electric) and students (users)	Product Design	73
	Tool Durability	80
	Tool Accuracy	80
	Effectiveness	83
	Tool Safety	83
Small Group Trial	Educational Value	71
	Relationship with teaching materials	73
	Product Design	70
	Tool Durability	70
	Tool Accuracy	69
	Effectiveness	72
	Tool Safety	69
Large Group Trial	Educational Value	71
	Relationship with teaching materials	73
	Product Design	70
	Tool Durability	73
	Tool Accuracy	70
	Effectiveness	70
	Tool Safety	70

In the small group trial, the results were obtained, the product design described the anatomy of the human arm, it was easy to touch the vein so that the cannulation failure rate decreased, besides that the simulator was also safe to use, describing educational values and in accordance with the teaching materials to explain the material of insertion and release of the infusion with an average value of 71%. The results of a large group trial with an average score of 71% indicated that the simulator was effectively used, depicting a human arm with an artificial vein that was easy to palp, safe and remained stable despite repeated cannulation.

In relation to this, the normality test is carried out as a prerequisite test to see if the learning outcomes are achieved well using the simulator and whether there is a difference in the value of practice using the simulator and using the manufacturer's phanthom. The results of the normality test obtained a significant value of 0.001, where the value  $< 0.005$ , the data was not distributed normally. So it use the Wilcoxon Signed Rank Test.

**Table 4. Wilcoxon Signed Rank Test**

Class	Wilcoxon Signed Rank	
	Z	Sig. (2 Tailed)
practice using the simulator and using the manufacturer's phanthom.	-2,036 <sup>b</sup>	0,039

Based on the test result presented in table 4 an Asymp value was obtained. Sig. (2-tailed) 0.039 ( $< 0.05$ ). Thus, it can be concluded that there is an effect/difference before and after the measurement on each individual on the value of the infusion insertion practice.

## DISCUSSION

The manufacture of silicone sleeves used for intravenous cannulation was formulated using research references conducted (Liu, 2023) although it does not accurately mimic the geometry and mechanical properties seen in different groups of patients. Formulation used in the manufacture of sleeves with the composition, silicone rubber (100) : catalyst ( 2 %). After the ingredients are mixed perfectly, they are placed on the mold and waited 24 hours to get maximum results.

The process of the intravenous cannulation simulator starts with running the uploaded code, and all components are ready for initialization where the Arduino Uno initializes every connected component, including the driver motor, YF-S201 flow sensor, and 16x2 I2C LCD. This initialization includes initial configuration, such as setting up communication with the sensor and setting up the LCD display to be ready to display data. Arduino reads data from the YF-S201 flow sensor, which generates a pulse signal whenever a liquid passes through the sensor. This signal represents the speed or volume of blood flow.

Based on the number of pulses received from the flow sensor, Arduino calculates the flow rate of blood. Arduino applies a predetermined formula or calibration to convert the number of pulses into a corresponding unit of flow rate, in mL per second. At this stage, the system will check if the blood flow rate is within a predetermined or desired range. If the flow rate is within the appropriate range, the system proceeds to the next stage. If the flow rate is not suitable, then the Arduino will send a signal to the driver motor to adjust the peristaltic pump speed so that the blood flow rate returns to the desired range.

The results of the blood flow rate measurement that have been calculated by Arduino are displayed on the 16x2 I2C LCD screen. This display allows users to see the value of blood flow rate in real-time. The process is complete after the data is displayed, but usually the system will go back to the previous step and continue to monitor the blood flow rate repeatedly (looping) for continuous monitoring. The Intravenous Cannulation Simulator is designed using a peristaltic pump as an artificial blood automatic driving motor. The Intravenous Cannulation Simulator is equipped with a flow sensor that functions as an artificial blood rate speed control made to adjust to the blood rate in humans, Artificial blood is flowed from a tube that is assumed to be the source of blood that flows blood to the veins in the arm. The inner arm is designed using silicone material and manipulated with a silicone tube and skin, making it easier for students to cannulate the vein.

Initial testing was conducted in the range of 0.08 – 1 ml/sec but artificial blood flow was very slow, making it difficult to cannulate. The next test was on the blood flow range when blood was first pumped from the heart (normal state), which was 80-83.3 ml/second, and obtained the stability value of artificial blood flow rate before the arm was cannulated, during cannulation and after cannulation, with an average value of 83.3 ml/second. This is in line with research conducted by (Munthe & Hutabarat, 2023) which explains that the water flow sensor can be used to calculate how much the speed of the water flow through the pipe, which will be displayed on the LCD screen, with a different speed value result every second, if the water pressure is enlarged/decreased then the measurement result will change automatically.

Similar tests on the flow response of the YF-S201 sensor were also carried out by (Supriyanto et al., 2021) with the results of the flowsensor readings showing the same average frequency values, namely 25 Hz and 35 Hz, where the data produced by the sensor will be processed by an Arduino uno microcontroller and displayed using software in the form of a monitor. Research (Gaikwad, Kamble, 2022) also explain the control Flow Sensor As a controller of the amount of water required and forced to flow through the pipes as per the code, so that the existing data will be sent to a cloud-based dashboard, so that this system effectively solves the problem of water discharge regulation.

Intravenous Cannulation Simulator use Flow Sensor YF-S401 as a blood flow rate monitor, trains students to perform IV cannulation with automatic blood flow at the same speed as normal human blood flow. The use of teaching aids is an important part for midwifery or nursing students, this aims to improve clinical skills related to the implementation of medical procedures in accordance with operational standards. Intravenous Cannulation Simulator aims to train students to

be competent in performing IV cannulation clinical procedures, so as to minimize errors in the practice field, because failure in venous insertion, will cause thrombophlebitis and trauma in patients (Kelly, 2023)

Intravenous Cannulation Simulator can be used as a practicum medium for infusion installation, IV therapy and sampling, but one of the drawbacks of this learning medium is that the prominence of veins in the arm is not depicted in artificial skin. This is the same as the research conducted by (Simeone et al., 2023) which states that although there is no statistically significant difference in the use of simulators, student satisfaction increases with clinical simulations and simulations support better skill acquisition. Other research by McWilliams et al., (2017) and Soepriyanto et, al (2019) explained that.

the results of different group tests using haptic IV simulators and without using haptic IV simulators obtained 53% of the group using haptic IV simulators were able to complete tasks well, this is empirical evidence that supports the effectiveness of simulators as a means to learn psychometric skills. Virtual intravenous simulator and VR technology have a positive effect on the intravenous injection performance of junior nursing students (Kim et al., 2024) .

This simulator has advantages compared to manufacturers' products, artificial blood is automatically flowed and the flow rate is displayed on the screen so that students can read it in real time, the blood flow range is adjusted to the normal blood flow speed range, and the artificial blood viscosity value is also designed to resemble human blood. Research (Arslan et al., 2022) about Effectiveness of simulation-based peripheral intravenous catheterization training for nursing students and hospital nurses by systematic review and meta-analysis methods with results from several studies it was found that there is no clear evidence of differences in Virtual IV training on PIVC-related skills, knowledge, satisfaction, and anxiety among nursing students and hospital nurses compared to training methods using artificial arms.

Medical treatment in Intravenous therapy is often done and is a stressful experience for clients. Proper intravenous cannulation, can provide comfort for the patient. This is an important part of learning in the laboratory to prepare graduates who are competent in performing IV clinical actions. The use of artificial arms is an effective learning medium in supporting students' skills when performing IV cannulation, this was explained by (Hernon et al., 2024) that students have independence and confidence in performing the procedural steps of peripheral intravenous cannulation, one of which is supported by exercises on simulators and manikins. Similar research was also conducted by (Marini et al., 2024) & (Wulandari et al., 2022) which mentions that the modified phantom developed can be used as a prop for infusion installation and blood collection based on existing needs, and the developed learning media can be used for practicum because it has a good appearance.

## CONCLUSION

The Intravenous Cannulation Simulator has achieved valid criteria for use in the practicum of IV installation, blood sampling and administration of intravenous therapy and the results of the students' perception test show that the product is effectively used to explain the insertion and release of the infusion material, blood sampling and the administration of intravenous therapy. The product is easy to cannulate and the blood flow velocity remains stable even when used repeatedly and depicts the anatomy of the human arm. The Intravenous Cannulation Simulator is expected to be developed with artificial skin that better depicts venous prominence so that it is easier for students to perform cannulations.

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