

Supplementary material

Table S1. *Characteristics of the included studies*

Study (Authors and year)	Country	Study Focus	Data collection methods/ Evaluation methods	Participants	Computer-based simulation platform	Features
Al-Dahir, Bryant, Kennedy, & Robinson, 2014 [51]	USA	To evaluate computer simulator as a learning method	Knowledge-based pre-post- Multiple- choice questions (MCQs) Evaluative survey - Likert scale	Pharmacy undergraduate s at one university.		
Neal Benedict, 2010 [36]	USA	Incorporating effective and active- learning strategies	Knowledge based questions. SOAP (Subjective- objective assessment-plan). Post course evaluative survey	Pharmacy undergraduate s at one university.		Automated marking/grading Immediate detailed feedback
Benedict, Schonder, & McGee, 2013 [28]	USA	To assess the effectiveness of computer simulation and promote self- directed learning	Pre and post knowledge quiz Final exam scores Post-course evaluative survey (Likert scale)	Pharmacy undergraduate s at one university	DecisionSim (Formerly vpSim) https://www.kynektiv.com/platform (Active)	Single user Different setting environment (Pharmacy + Interdisciplinary) Support sharing scenarios
Lichvar et al., 2016 [66]	USA	To design and evaluate the integration of a virtual patient activity And study an effective active- learning strategy.	Pre and post knowledge quiz End-of-year exam (To assess knowledge retention) evaluative survey (Likert scale and open-ended questions)	Pharmacy undergraduate s at one university.		Video, Audio, and Imagery (Web-based)
Olin & Cole, 2015 [55]	USA	To describe computer-based clinical	Evaluative survey (Likert scale)	Pharmacy undergraduate		

		simulation cases (CBCSCs) and review student perceptions of this learning strategy.		s at two campuses		
Michael A. Smith, Mohammad, & Benedict, 2014 [4]	USA	To assess student satisfaction and learning of course objectives	The post-course survey, and a pre-simulation and post-simulation tests were used to assess student learning	Pharmacy undergraduate s at one university		
Michael A. Smith, Siemianowski, & Benedict, 2016 [29]	USA	To expand the use of virtual patients by sharing case scenarios across two schools	Pre and post-tests assessed student learning, data collected regarding the development and sharing of cases and the survey was conducted to measure faculty perception and student satisfaction	Pharmacy undergraduate s and 3 educators at two schools.		
Ambroziak, Ibrahim, Marshall, & Kelling, 2018 [12]	USA	To evaluate a computer simulator and assess the dispensing knowledge	Post-course survey (with open and closed-ended questions)	Pharmacy undergraduate s at one university.		Automated marking/grading
Ferrone, Kebodeaux, Fitzgerald, & Holle, 2017 [41].	USA	To evaluate computer simulator and assess the dispensing knowledge and student perception	post-simulation survey, (Likert scale and open-ended questions)	Pharmacy undergraduate s at three Universities	MyDispense	Immediate detailed feedback Single user One pharmacy setting
Mak, Fitzgerald, Holle, Vordenberg, & Kebodeaux, 2021 [11].	Australia	Improve student learning	A commentary from authors and developers of the tool to share suggestions for using "MyDispense" in the didactic and experiential settings to meet	Pharmacy undergraduate s	https://info.mydispense.monash.edu/ (Active)	Support sharing scenarios Static images, Text, and Patient notes (Web-based)

educational outcomes and the challenges of virtual simulation.						
McDowell, Jenny Styles, Kim Sewell, Keith Trinder, Peta Marriott, Jennifer Maher, Sheryl Naidu, Som, 2016 [54].	Australia	To develop and evaluate a computer simulator and assess student knowledge.	Analysis of student examination results and post-course survey.	Pharmacy undergraduates at one university.		
Shin, Tabatabai, Boscardin, Ferrone, & Brock, 2018 [43]	USA	To demonstrate the feasibility of integrating computer simulation and assess student perceptions	pre- and post-tests in class and three surveys (for each phase and overall experience)	Pharmacy undergraduates at one university		
Tai, Ming-Hei Rida, Nada Klein, Kristin C Diez, Heidi Wells, Trisha Kippes, Kellie Walker, Paul C Vordenberg, Sarah E, 2020 [21].	USA	Assess student perception and knowledge in introductory pharmacy practice experiences (IPPEs)	Post-course surveys were conducted by students. Also, preceptors were asked to complete a survey.	Pharmacy undergraduates and preceptors at one university		
Richardson, Chapman, & White, 2019 [59].	different European countries	To develop and show proof of concept of the computer-based simulation.	a blend of formal meetings, distance evaluation (Using formal forms and email feedback). Evaluation forms were a mixture of quantitative and qualitative questions.	A steering group of European pharmacists provided data for computer simulation development	Keele virtual patient (Keele University) https://www.keelevp.com/ (Active)	Grading was not offered (but suggested by users) Immediate detailed feedback Single user Different setting environment (Pharmacy + Interdisciplinary)

Thompson, Jessica White, Simon Chapman, Stephen, 2020 [13].	UK	To evaluate perceptions on the integration of computer simulator.	Telephone interviews (Semi-structured) to discuss the students' perspectives on the use of the virtual patient or non-interactive case studies	Pharmacy undergraduate (pre-registration) at one university	Support sharing scenarios
Thompson, Jessica White, S. Chapman, S., 2020 [44].	UK	To evaluate virtual patient (VP) and non-interactive (NI) case studies, concerning knowledge, skill, and confidence development.	Pre- and post-knowledge quiz. questionnaire (Likert scale and open-ended questions).	Pharmacy students (preregistered) at one university	Interactive animated avatar, Embedded voice and Dynamic emotions, Patient notes and Dialogue choices options
Bracegirdle & Chapman, 2010 [58].	UK	To demonstrate the computer simulator design and report the integration experience	collective feedback	Pharmacy undergraduates at one university	
S. B. Duffull & Peterson, 2020 [57].	New Zealand	to evaluate students' perceptions using the computer simulation	Post-course evaluative survey. (Likert scale)	Pharmacy undergraduates at one university	Automated grading Immediate feedback
Duffull, Stephen. Peterson, A. K. Chai, Bill Cho, Frasier Opoku, Justice Sissing, Tasia Smith, Daniel Tongskul, Tran Wilby, K., 2020 [56].	New Zealand	To evaluate the use of the computer simulation in interprofessional education (IPE)	A post-course questionnaire, an interview, and a review of students' SimPHARM log files.	-Medical and pharmacy undergraduates at one university.	SimPharm https://www.simpharm.com/ (Active)
Loke, Swee-Kin	New Zealand	To evaluate the learning method	Audio recordings and	Pharmacy undergraduate	Single user Different setting environment (Pharmacy + Interdisciplinary) Support sharing scenarios Static images, Audio, Text, and Patient notes (Web-based)

Tordoff, June Winikoff, Michael McDonald, Jenny Vlugter, Peter Duffull, Stephen, 2010 [32]		using a computer simulator and students' perception	observations in class Focus groups	s at one university.		
Wright, Daniel F. B. Duffull, Stephen B. Wilby, Kyle J. Peterson, Aynsley K. Anakin, Megan G., 2020 [45].	New Zealand	To evaluate knowledge and skills delivered by the computer simulator	A pre-and post- intervention crossover study design	Practising pharmacists.		
Bravo, Marie Jam So, Miranda Natsheh, Cindy Tait, Gordon Austin, Zubin Cameron, Karen., 2019 [60].	Canada	To assess students' perceptions using a computer simulation	a semi-structured interview conducted by VIC's project team members. The interviews were audio- recorded, transcribed, and coded for extracting themes.	Pharmacy undergraduate s from one university	Virtual Interactive Case System	Automated marking/grading Immediate detailed feedback Single user Different setting environment (Pharmacy + Interdisciplinary) Support sharing scenarios
Dahri, Karen MacNeil, Kimberley Chan, Fong Lamoureux, Emilie Bakker, Mattie Seto, Katherine Yeung, Janice., 2019 [35].	Canada	To investigate students' perceptions towards computer simulation	Post-course survey and focus group participation	Pharmacy undergraduate s at one university	http://pie.med.utoronto.ca/VIC/VIC_content/VIC_pharm.html (Active)	Static image and Text With limited choices option (Web-based form)
Bindoff, Ivan Ling, Tristan	Australia	To present and evaluate the computer	Pre and post knowledge quiz	Pharmacy undergraduate	Pharmacy Simulator	Automated marking/grading

Bereznicki, Luke Westbury, Juanita Chalmers, Leanne Peterson, Gregory Ollington, Robert., 2014 [16].		simulator's effectiveness and actively engaging learning experience	Evaluative survey (Likert scale and open-ended questions)	s from one university	https://www.pharmacysim.com/ (Active)	Immediate detailed feedback Single user In more than one pharmacy setting Support sharing scenarios Interactive animated avatars, Embedded voice and Dynamic emotions, Patient notes and Dialogue choices options
Tait, Lauren Lee, Kenneth Rasiah, Rohan Cooper, Joyce M. Ling, Tristan Geelan, Benjamin Bindoff, Ivan., 2018 [67].	Australia	To investigate perception and experience using computer simulation	A post-simulation questionnaire.	Master of Pharmacy students at one university		
Zary, Johnson, Boberg, & Fors, 2006 [38].	Sweden	To evaluate a computer simulator	Post-course surveys and on-site observations were performed when possible. (Likert scale and free text Comments)	Medicine, dental and pharmacy undergraduates	Web-based Simulation of Patients (Web-SP).	Automated marking/grading Immediate detailed feedback Single user Different setting environment (Pharmacy + Interdisciplinary) Support sharing scenarios Video, Audio, and Imagery and/or free text input.
J. L. Marriott, 2007 [52].	Australia	To assess and evaluate a computer simulator's use as a learning tool	Post-assessment survey) to determine the	Pharmacy undergraduates at one School/University	A purpose-designed computer program	No marking/grading Delayed detailed feedback

		program's ease of use and its perceived value.		Single user	
				Different setting environment (Pharmacy + Interdisciplinary)	
J. L. Marriott, 2007 [53].	Australia	To assess and evaluate a computer simulator's use as a learning tool	Review of the software design, features, and functions	Pharmacy undergraduates at one School/University	Shareable scenarios: no information
				Preselected options and/or text.	
				Need faculty marking/grading	
				Immediate detailed feedback	
				Multiple users	
Caylor, Aebersold, Lapham, & Carlson, 2015 [40].	USA	to examine the use and effectiveness of the computer simulation in multi-professional learning	Pre and post teamwork Questionnaire (Likert scale) Team Performance Observation Tool – Faculty members	Undergraduates from nursing, medicine, and pharmacy at same University	Second Life
				Different setting environment (Pharmacy + Interdisciplinary)	
				Shareable scenarios – not supported	
				Animation based and voice discussion through avatars	
				Automated marking/grading	
				Immediate detailed feedback	
				Single user	
Benedict & Schonder, 2011 [15].	USA	To implement and assess the effectiveness of a computer simulation in teaching	Pre and post knowledge quiz Final exam scores	Pharmacy undergraduates from one university	PharmaCAL
				In one pharmacy setting	
				Sharing scenarios – not supported	
				- Development: University developed	
				- Output: No info	
				- Input: Preselected options.	

Douglass, Casale, Skirvin, & DiVall, 2013 [68].	USA	To implement and assess the impact of computer simulation on students' knowledge and skills	Pre and post-test for evaluating clinical competence	Pharmacy undergraduates at one university.	TheraSim	Automated marking/grading
						Immediate detailed feedback
						Single user
						In one pharmacy setting
						Support sharing scenarios
Fuhrman, Buff, Eaddy, & Dollar, 2001 [63].	USA	To present and implement a virtual patient database in teaching continuity of care	Students graded on their responses Knowledge exam. Post-course evaluative survey. (Likert scale)	Pharmacy undergraduates at one university	Virtual Family	Video, Audio, and Imagery and preselected options
						Need faculty marking/grading
						Immediate detailed feedback
						Multiple users
						In one pharmacy setting
Hussein & Kawahara, 2006 [47].	USA	To promote active learning and knowledge	Knowledge assessed based on 1) the care plan and messages left on the telephone 2) Final knowledge exam Also, Educators' evaluative Survey. (Likert scale) Students' evaluative Survey.	Pharmacy undergraduates and six faculty members at one university	Computer telephony interactive voice response system (IVR) and a text-to-speech (TTS) system.	Sharing scenarios – not supported
						Text-based
						Need faculty marking/grading
						Delayed detailed feedback
						Single user
						In one pharmacy setting
						Sharing scenarios – not supported
						Voice- telephone-based and Text-based

							Support sharing scenarios
							Interactive animated avatar and Preselected options
							Needs faculty marking/grading
							Delayed detailed feedback
							Single user
J. Marriott, Styles, & McDowell, 2012 [31].	Australia	To present a computer simulator and the integration experience within teaching the curriculum	Post-course students' feedback survey for two consecutive years. A student focus group discussion was conducted. A comprehensive evaluation was undertaken of staff and student use of Pharmville.	Pharmacy undergraduates	Pharmville	In one pharmacy setting	Support sharing scenarios
							Include: Video, Audio, and Imagery (Web-based) and/or free-text input
							Needs faculty for marking/grading
							Delayed detailed feedback
							Single user
Menendez et al., 2015 [39].	Brazil	To present and evaluate computer simulation in teaching	Post-course surveys and on-site observations were performed when possible.	Pharmacy undergraduates at one university.	PharmaVP	In more than one pharmacy setting	Sharing scenarios – not supported
							Include: Video, Audio, and Imagery (Web-based) and/or free-text input
							Needs faculty for marking/grading
Park & Summons, 2013 [65].	Australia	To present a computer simulator and students' perceptions	Evaluative survey – Likert scale	Pharmacy undergraduates at three universities	The Virtual Pharmacy Patient	Delayed detailed feedback	Single user

Villaume, Berger, & Barker, 2006 [42].	USA	To assess students' knowledge using computer simulation	Post assignment survey was conducted to collect feedback regarding students' experiences with the tool.	Pharmacy undergraduate s	The Auburn University Virtual Patient (AUPV) simulation.	Needs faculty marking/grading
			knowledge test (by number of multiple choice questions (MCQs) as part of the final examination to examine students' knowledge retention and efficiency of incorporating the tool.			Delayed detailed feedback
Barnett, Gallimore, Pitterle, & Morrill, 2016 [37].	USA	To evaluate computer simulation vs a paper case on student confidence and engagement.	Students script for VP - graded Final exam – Knowledge retention	Pharmacy undergraduate s at one university	Case Scenario/Critical Reader (CSCR) Builder authoring tool	Single user
			Pre- and post-evaluation survey (Likert scale)			In more than one pharmacy setting
Battaglia, Kieser, Bruskiwitz, Pitterle, & Thorpe, 2012 [50].	USA	To present the development, implementation, and assess the effectiveness of	Subjective-objective assessment plan (SOAP)	Pharmacists (42) and pharmacy students at one university	Virtual patient training via the online Moodle platform.	Sharing scenarios – No information
			Pre and post assessment (Likert scale, multiple choice questions (MCQs))			Video, Audio, and Imagery and Text-based
						Needs faculty marking/grading
						Delayed detailed feedback

		computer simulation	and short answer questions)			(Multiple users)
						In diff pharmacy settings + other health education
						Support sharing scenarios
						Text-based
						Needs faculty marking/grading
			Pre- and post-surveys			Delayed detailed feedback
Coons, Kobulinsky, Farkas, Lutz, & Seybert, 2018 [69].	USA	to evaluate the impact of a virtual EHR on learning efficiency	Well as a clinical pharmacy note which summarised a problem list and treatment recommendations.	Pharmacy undergraduates at one university	Virtual EHR/DocuCare	Single user
						In diff pharmacy settings + other health education
						Support sharing scenarios
						Preselected options and/or free-text input
						Needs faculty marking/grading
			Pre- and post-activity surveys			Delayed detailed feedback
		To measure students' confidence and assess their performance and perception using EHR technology.	As well as performance scores were compared between students that used an EHR vs last year's students who used a paper-based medication form.	pharmacy undergraduates at one university	EHR GO! https://ehrgo.com/	Single and multi-user
Ives, Tucker, & Trovato, 2020 [70].	USA				https://ehrgo.com/	In diff pharmacy settings + other health education
					(Active)	Support sharing scenarios
						Static images, Text, and Patient notes (Web-based)

Active: There is an available presence of the simulator's website, which offers new updates and shows specialised interest in Pharmacy education.

Inactive: There is (NO) available presence of the simulator's website or (NO) available updates or shows (NO) specialised interest and/or availability of scenarios focusing on Pharmacy education.